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SOCIAL CLASS DIFFERENCES IN THE ROLE OF LINGUISTIC STRUCTURES IN PAIRED-ASSOCIATE LEARNING, ELABORATION AND LEARNING PROFICIENCY.

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THE REPORT DESCRIBES 13 EXPERIMENTAL STUDIES OF LEARNING IN CHILDREN BETWEEN FOUR AND 12 YEARS OF AGE. THE EXPERIMENTS CONCERN--(1) THE ISOLATION CONDITIONS UNDER WHICH ELABORATIVE FACILITATION OF LEARNING OCCURS, AND (2) THE RELATIONSHIP BETWEEN ELABORATION AND INDIVIDUAL DIFFERENCES IN LEARNING PROFICIENCY. BECAUSE CHILDREN LEARN NOUN PAIRS AND SERIAL LISTS OF NOUNS MORE RAPIDLY WHEN THESE ARE PRESENTED IN A GRAMMATICAL VERBAL CONTENT, SEVERAL EXPLANATORY HYPOTHESES WERE SUBJECTED TO EMPIRICAL TESTS IN THE FIRST STUDY. THE RESULTS INDICATE THAT NOTIONS SUCH AS INTRA-LIST SIMILARITY, SEMANTIC CONSTRAINT, CONTEXT AVAILABILITY, IMPLIED OVERT ACTIVITY, AND VARIATIONS IN FUNCTIONAL STIMULI ARE INADEQUATE. THE REMAINING VIABLE HYPOTHESIS CONCERNS THE UNDERLYING SYNTACTICAL STRUCTURE OF VERBAL CONTESTS. FINALLY, PICTORIAL CONTESTS, ISOMORPHIC WITH THE VERBAL CONTESTS STUDIED, WERE FOUND TO PRODUCE PARALLEL FACILITORY EFFECTS. THE SECOND PROBLEM EXPLORED VARIATIONS IN THE EFFECTS OF ELABORATION AMONG CHILDREN CLASSIFIED BY AGE, SOCIOECONOMIC STATUS (SES), AND INTELLIGENCE. BOTH VERBAL AND PICTORIAL ELABORATION WERE EFFECTIVE ACROSS THE AGE RANGE AND EQUIVALENCE IN LEARNING PROFICIENCY WAS OBSERVED ACROSS SES GROUPS EXCEPT WHEN REPETITION WAS IMPORTANT FOR PERFORMANCE. A TEST WAS DEVELOPED FOR THE PURPOSE OF INDEXING LEARNING ABILITY. INTELLIGENCE TESTS ARE NOT PREDICTIVE OF LEARNING PROFICIENCY AMONG LOW-SES CHILDREN, ALTHOUGH THEY ARE FOR MIDDLE-SES CHILDREN. (AUTHOR)

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SOCIAL CLASS DIFFERENCES IN THE ROLE OF LINGUISTIC STRUCTURES IN PAIRED-ASSOCIATE LEARNING

Elaboration and Learning Proficiency

November, 1967

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Project No. 5-0605
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William D. Rohwer, Jr.

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Introduction

Psychological research has revealed much about processes involved in human learning. Some of the most important of such processes, however, have received relatively little attention to date. Among these are to be found activities engaged in by the learner when faced with the task of assimilating materials presented for acquisition. Systematic research on learning efficiency as a function of learner activities is of relatively recent vintage and only a limited literature of relevant empirical work is available as yet. Nevertheless, enough has been accomplished to permit the kind of subdivision of the general problem necessary for further progress.

At least two major kinds of learner activities may be distinguished: reduction and elaboration. Conceptually, the effects of the former kind of activity on learning efficiency are easily comprehensible. In reduction, the learner simplifies his task by selecting for attention and complete processing only those aspects of stimulus materials that are essential for correct performance. Probably the best known and most thoroughly investigated instance of reduction is that of stimulus selection (41). Results of research lead to the sensible conclusion that the economy achieved by reduction activities results in savings in learning time. Few expectations are violated by the fact that less material can be learned with greater ease than more material.

In contrast, the effect of elaborative activities on learning efficiency appears paradoxical. As the meaning of the rubric implies, elaboration involves the addition of units to those the learner is formally asked to acquire such that the nominal result is more material to be processed than required by the task as it is originally presented. Yet, for specifiable kinds of elaboration, increases in the amount of material result in corresponding increases in learning efficiency. Thus, the paradox is posed: more material is easier to learn than less.

The elaboration paradox is one of the two major foci of the research that will be described in the present report and a detailed examination of it will be made shortly. The second focus of the research to be reported is the relationship between socioeconomic status (SES), elaboration and learning efficiency. As measured by performance on standardized tests of intelligence or of school achievement, students attending low-strata schools, that is, schools serving low-SES residential areas, have less proficiency in learning than students attending high-strata schools (43). For present purposes, the problem posed by this observation is to determine whether the strata differences revealed by performance on standardized tests can be detected in performance on learning tasks. That is to say, the question is whether or not performance on tests that require the recall of what has been learned in the past is isomorphic with performance on tasks that demand relatively new learning. If the same discrepancies previously found on standardized tests are found on learning tasks as well, the next objective is to determine the conditions under which the performance of low-strata children can be made equivalent to that of high-strata children. At the outset, the guiding hypothesis in this regard is that the induction of elaborative activities in low-strata children may suffice to accomplish this objective.

Thus, the present project has two purposes. The first is primarily theoretical, namely, to construct and evaluate empirically explanations of the phenomenon of elaborative facilitation of learning. The second purpose is to explore the implications of what is discovered about the role of elaboration in learning for the problem of SES related differences in learning proficiency.

Elaborative Facilitation

The meaning of the term elaboration will be clarified and the present status of knowledge about the role of such activities in human learning will be described by reviewing relevant research that is now available. Before proceeding to the review, however, it is in order to provide a brief justification for introducing the term elaboration in a field already replete with specialized terminology.

As will become evident, elaboration refers to processes and events related to learning which are in excess of those involving simply stimuli and responses. But this property is not unique and by itself would not warrant designation with a new term. Events that intervene between stimulation of an organism and his subsequent response to that stimulation have been studied intensively under the topic of mediation, a topic that has a relatively long history in psychological research on learning. Similarly, events, processes and conditions, that form the past history of an organism and that are relevant to performance on a learning task have been subjected to considerable experimental analysis. The results of these efforts have yielded the specification of pre-experimental factors that affect learning. Accordingly, it appears superfluous to introduce a term like elaboration when its referents could be subsumed under existing topics in the psychology of learning.

Unfortunately, however, the subsumption of a relatively little understood phenomenon within a category about which much is known produces the conviction that explanation has been achieved. Thus, despite the economy that would ensue, it is provident to resist the premature referral of elaborative phenomena to a well-known process such as mediation. Consequently, the first order of business is to review and examine evidence pertaining to the occurrence and the nature of elaboration.

The first question to be considered is whether or not subjects (Ss) engage in elaborative activities when they learn. A suggestive answer has been provided by investigators such as Bugelski (4) and Runquist and Farley (35). In connection with tasks that nominally involve only rote learning, typically paired associate (PA) learning, Ss were queried, at the completion of the task as to any strategies they may have used to associate the two items in each pair. The reports made in response to such questions indicated that college-age Ss do indeed engage in activities that augment or expand the elements they are asked to acquire. Runquist and Farley (35), for example, found that Ss often reported the expansion of the two items in each pair in the form of a sentence ("The distinct west of old was lawless."). The frequency of reported elaboration is found to vary both across Ss within an experiment and across items in a PA list but the fact that college-age Ss can make such reports has been reliably established.

The issue of the role of such elaborative activities in the processes of PA learning, however, is not clarified by these results. The method of retrospective subjective reports of activities purportedly occurring during learning does not, by itself, permit inferences crucial to the issue. The method yields results that are ambiguous with respect to whether elaborations are constructed during the course of acquisition trials or only afterwards in response to experimenters' queries. If it is the former, complete uncertainty still remains as to when elaboration initially occurs for a given pair. Finally, retrospective reports yield no evidence relevant to the question of the relationship between elaboration and the efficiency of learning.

Although some of these limitations are inherent in the nature of retrospective reports, some can be reduced by additional data analyses. Two kinds of such analyses have been reported. In one of these, an examination is made of the relationship between whether or not elaboration is reported for a given item in a PA list and the ease or difficulty with which that item is mastered (4). In general, those items for which elaboration is reported are learned more readily than those for which it is not. A more complex way of inquiring about the relationship between elaborative activities and learning efficiency has been used by Martin and by Montague and their respective associates (2, 18, 20, 21, 22, 23). Again, the primary data are yielded by Ss' retrospective reports of their activities during the learning of a PA list. Before the existence of a relationship between elaboration and efficiency is appraised, however, S's reports for each pair in a list are categorized in accord with a scheme that permits classification along a dimension of complexity that ranges from no activity and rehearsal at the simple end to the use of grammatical elaboration at the complex end (20, 21). When reported elaboration (called associative strategies by Martin et al and natural language mediators, NLMs, by Montague and Kiess /18, 23/) is thus classified, it is found that the more complex the elaboration reported for a pair, the more rapid has been the acquisition of that pair during the learning trials. In this manner, evidence suggests the reliability of non-causal relationships between elaboration and learning efficiency, at least in college students.

In order to make strong inferences as to whether or not elaboration affects learning efficiency, a methodology other than that of self reports must be used. Rather than correlating the occurrence and complexity of reported elaboration with the rate at which given PAs are learned, it is necessary to manipulate elaborative activities by explicit procedures and observe the effect on learning efficiency. At least two ways are available for doing this: first, by varying instructions with respect to encouraging or discouraging elaborative activity; and, second, by varying the amount of elaboration with which materials are presented for learning. If successful, the advantage of either of these methods over that of self reports is clear; it is that results produced by experimental manipulation of elaborative activities permit a decision as to whether or not learning efficiency is a function of elaboration.

Despite the appeal of an experimental approach to the problem of elaboration, unambiguous results cannot be expected to follow automatically from it. Two limitations of the approach are worthy of special mention. The first, and less serious of the two, concerns the kinds of subject populations most appropriate for sampling. Neither in the case of instructed nor in that of presented elaboration, can the initiation of elaborative activities by the learner be fully controlled. Ideally, Ss selected for experimentation would engage in only those elaborative activities under the control of the experimenter. But, as the studies already reviewed have suggested, college students elaborate learning materials even when they are not instructed to do so. Consequently, these kinds of Ss do not constitute the population of choice for conducting experimental investigations of elaboration and its effects on learning. In contrast, populations of pre- and elementary-school children as well as mentally retarded young adults are not characterized by a propensity spontaneously to engage in elaboration. Even though it cannot be presumed that elaborative activities are entirely absent in persons drawn from these populations, there is evidence that their frequency is relatively low (10). This is to say that the first limitation on an experimental approach is not debilitating.

The second limitation of the experimental approach cannot be disposed of so easily. Indeed, it probably cannot be disposed of at all since it is inherent in the method. The strength of the experimental approach lies in the fact that variations in the independent variables examined are under the control of the experimenter but it is precisely this property of the method that removes the behavior to be observed from the domain of naturally occurring phenomena. Specifically, in the case of experimental studies of elaborative activities, the manipulation of elaboration prevents the investigator from making claims directly about the nature of elaboration as it naturally occurs. That is to say, regardless of the results obtained through manipulating either elaboration instructions or presented elaboration, it remains indeterminate whether or not the results apply to elaboration as it naturally occurs. Nevertheless, such results seem to be the most reliable and persuasive kind of information that can be made available about processes such as those involved in elaboration, that is, processes which are by no means open to direct observation.

Elaboration was manipulated by instructions in a developmental study reported by Jensen and Rohwer (16). Samples of kindergarten, second-, fourth-, sixth-, eighth-, tenth- and twelfth-grade Ss were asked to learn successively a 12-item PA list and a 12-item serial list of pictures of common objects. The order of the tasks was counterbalanced and half the Ss in each order were given elaboration instructions while the other half were not. In the case of the PA task, when the pairs were first presented during the initial trial, the elaboration instructions asked the S to construct and utter aloud a sentence containing the names of each of the two objects in every pair presented (e.g. The SHOE fell on the BED). The control condition instructions only required Ss to utter the names of the two objects in each pair as they were presented. Elaboration instructions for the serial learning task directed the S to construct and utter aloud a sentence containing the names of every adjacent pair of pictured objects in the serial list such that 11 sentences were required. In the control condition, Ss simply uttered the names of the objects in the list as they were presented. Note that the procedure followed after the initial trial in the case of both the elaboration and control conditions was identical for the PA and for the serial tasks; an anticipation method was followed until the criterion of one perfect trial was reached and no additional requests were made for reproduction of the sentences.

The results for the serial task indicated that elaboration instructions did not increase learning efficiency. Indeed, as the investigators concluded, this form of instructed elaboration seemed irrelevant to the process of serial learning. In contrast, marked facilitation of learning was found for second-, fourth-, sixth-, and tenth-grade children in the elaboration condition provided for the PA task. Relative to the control condition, the sixth-graders, for example, required 10 times fewer trials to reach criterion when given elaboration instructions.

No significant facilitation was observed in the remaining samples: kindergarten, eighth, and twelfth grades. The fact that learning efficiency was less affected by elaboration instructions in the case of the older children is consistent with the notion that self-initiated elaboration occurs in members of these populations. In contrast, the absence of facilitation in the kindergarten group provoked the question whether children of this age are developmentally incapable of deriving benefit from this form of elaboration or if they simply have difficulty in carrying out the elaboration instructions, that is, in generating sentences, under the constraints of the PA task.

Similar tasks and experimental designs were used in two other studies conducted with samples of mentally retarded adults (13, 14). In these experiments, however, elaboration was not manipulated by instructions. Instead, Ss in experimental conditions were provided with sentences by the experimenter (E) for each of the pairs in the PA list and for the series of adjacent items in the serial list. Again, marked facilitation was produced by elaboration in the case of the PA task, but not for serial learning.

The results of these three experiments demonstrated that sentence elaboration does affect learning rate. Unfortunately, however, this conclusion must be tempered in view of the fact that the procedures in the three experiments reviewed were informal in two senses. First, amounts of study time in the elaboration and control conditions were not necessarily equal; Ss were allowed to pace themselves which may have resulted in more time per trial for those instructed to generate sentences and for those presented with sentences than for those in the control conditions. Secondly, no attempt was made to manipulate systematically the kinds of sentences that were presented or the kinds that were constructed in the instruction procedure.

In a study reported by Rohwer (33), however, both of these problems were eliminated. This study represents an initial attempt to analyze experimentally the phenomenon of sentence-produced facilitation of PA learning. The materials to be learned consisted of eight pairs of high-frequency nouns rather than pictures as was the case in previous studies. With the exception of the control condition, these nouns were presented to all Ss in the context of one or another of several kinds of verbal strings during the initial trial and only during that trial. The various experimental conditions were distinguished by the character of these pretraining strings. The procedure for all subsequent trials was identical for all groups; a standard PA anticipation method was used. The first trial for the control group simply consisted of the successive presentation of each of the eight pairs of nouns; as each pair appeared in view, the S read the two nouns aloud.

Three properties of the contextual verbal strings were manipulated: Meaningfulness (English word vs. nonsense word strings); Syntax (grammatical word order vs. scrambled word order); and connective form class (conjunction vs. preposition vs. verb). Every string was comprised of seven words representing the following classes of forms in the following sequence: article-adjective-noun-connective-article-adjective-noun. It is important to remember that regardless of variations in the manipulated properties of the strings, the nouns were identical across all the conditions.

Sixth-grade children drawn from schools serving an upper-middle class residential area served as Ss. The task was paced by the experimenter in such a way that only four seconds were allowed for the reading of each of the strings during the pretraining trial and for the S to correctly anticipate the second noun in each pair when shown the first.

The results were quite clear. Relative to performance observed in the control condition, only in those groups given structured, English-word strings on the pretraining trial, was learning facilitated. Neither syntactical strings in the absence of meaningful words, nor meaningful words in the absence of syntactical ordering affected the observed efficiency of learning. Thus it was possible to conclude that both of these properties that had characterized the sentences used in previous investigations, that is, grammaticality and meaningfulness, are necessary for the emergence of the facilitation observed.

Of even greater potential interest, however, was the result obtained in connection with variations in the third factor, namely that of connective form class. For the performance observed implied that grammaticality and meaningfulness are not sufficient to guarantee that linguistic elaboration will facilitate the learning of constituent noun pairs. Recall that three form-class conditions were used. The strings presented in the three conditions were identical except for the connective: conjunction (e.g. The running COW and the bouncing BALL); preposition (e.g. The running COW behind the bouncing BALL); and, verb (e.g. The running COW chases the bouncing BALL). In the conjunction condition, the number of correct responses made during learning was no greater than that made in the control condition. The preposition and verb conditions, however, produced significantly larger numbers of correct responses than were observed in the control condition. The superiority of the verb over the preposition condition obtained in this sample was not significant. Thus, the results demonstrated that only particular kinds of linguistic elaboration facilitate learning and that the facilitation produced relative to the control condition was not attributable to extended amounts of study trial or learning time.

The results of the Rohwer experiment (33) raise a number of questions. All of these are concerned with accounting for the observed effect; Why do preposition and verb strings facilitate the acquisition of constituent noun pairs? The present project was planned to evaluate three proposed answers to this general question. The first is that verb and preposition strings facilitate learning because they render each of the stimulus terms in a list of PAs maximally dissimilar, and thereby reduce the amount of intralist interference occurring during learning. A more detailed account of the argument for this interpretation will be given in connection with the experiment designed to test it.

The second explanation to be evaluated was phrased in terms of the notion of constraint. Given the knowledge of two words and that the two words along with an unknown third word from a meaningful string, if the given words are a noun and a verb, the number of alternative, appropriate third words is much smaller than if the two given words are a noun and a conjunction (cf. "Horses eat _____." with "Horses and _____"). The assumption is that verbs exert more constraint on subsequent words in grammatical strings than do conjunctions. If so, exposure to noun pairs in the context of verb strings would be expected to increase the probability that the second noun of a pair could be correctly selected for recall when the first is later shown as a cue. An experiment to be described later was designed to test this hypothesis.

The third explanation proposed for evaluation requires more documentation than the previous two. It rests on the assumption that verbal material of whatever kinds of units, words, phrases, sentences, evokes covert imagery processes when presented for learning. If so, it is variations in properties of the evoked images that determine learning efficiency directly, rather than properties of the verbal units that constitute the nominal learning materials.

The justification for inquiring into the possibility that underlying facilitative process in sentence elaboration is pictorial rather than verbal lies in the results of two lines of experimentation. The first line is represented by three studies concerned with the facilitation of PA learning through the use of pictures depicting relationships between two objects. Epstein, Rock and Zuckerman (9) found that the presentation of pictures of object pairs to adults produced better recall when the two members of each pair were joined (e.g. a drawing of a HAT on a TABLE) than when they were not (e.g. a drawing of a HAT and a drawing of a TABLE). Similarly, Davidson (6), reports that second-grade children learn pictorial PAs more rapidly when the two items are depicted in some kind of relationship (e.g. a drawing of a CHAIN inside a BOWL) than when depicted independently (e.g. a drawing of a CHAIN and a drawing of a BOWL). In a factorial experiment with young children, Reese (32) found that the presentation of picture pairs drawn so as to depict interactions between the two members (e.g. a picture of a CAT carrying an UMBRELLA) produced nearly as much facilitation as the presentation of independent pictures in conjunction with a phrase describing the interaction (e.g. "CAT carrying an UMBRELLA").

The second line of research that precipitates the present concern with an imagery explanation of the facilitory effect of sentence elaboration has been prosecuted almost entirely by Paivio, his coworkers and his students (25, 26, 27, 28, 46). In brief, one of the implications of a series of experiments with both adults and children is that a substantial portion of variance in the difficulty of learning verbal PAs is accounted for by the rated capability of words for evoking representational images. The power of imagery ratings for predicting learning efficiency remains most impressive even when differences between items with respect to inherently verbal variables such as frequency, $\underline{m}$ and pronounceability have been eliminated.

In this connection, one of the objectives of the research proposed for the present project was to determine whether a pictorial dimension of elaborative facilitation could be detected. More specifically, the goal was to ascertain whether such a pictorial dimension constructed by direct analogy from the verbal form-class dimension already established would produce effects on learning efficiency that were essentially parallel to those produced by the latter dimension. If so, the next step was to initiate exploration of the question which of the two dimensions has primacy in the development of facilitory elaborative activities.

Elaboration and Learning Proficiency

The second major purpose of the research to be reported was to advance understanding of the observed discrepancy between the learning proficiency of children in upper-strata schools and that of those in lower-strata schools. Indices of learning proficiency that make this discrepancy visible are those of standardized school achievement tests and commonly used tests of intelligence. Typical observations indicate that the size of the discrepancy, which almost invariably favors upper-strata children, increases from the first to the sixth years of elementary school (3, 38, 43). The problems presented by this discrepancy are those of isolating the factors responsible for it, of determining whether or not it can be ameliorated by educative means, and, if so, of designing specific methods for successfully doing so. The present project has direct relevance for the first two of these problems.

A number of hypotheses have already been advanced in connection with the first-named problem, that of isolating the factors responsible for the observed discrepancy in learning proficiency. Only two of these hypotheses will receive close attention here. One contends that the discrepant performance of lower-strata children on standardized tests is a direct reflection of deficiencies in learning ability. In contrast, the other hypothesis holds that low performance on standardized tests on the part of low-strata children is principally a function of the fact that such children make insufficient use of elaborative activities when confronted with learning tasks.

These two hypotheses have very different implications. Before exploring these, however, it is important to clarify the status of standardized tests as measures of learning ability. A crucial characteristic of such tests is that opportunity for learning is assumed equivalent for all testees of the same chronological age or of the same school grade. The notion of opportunity consists of two related parts: exposure to relevant learning materials prior to the testing session; and, attention to and amount of practice with those materials. The tests themselves, whether they are classified as indices of intelligence or of particular kinds of school achievement, measure principally what a child has retained of what he has learned in the past. Clearly, then they do not measure the efficiency of learning directly. Performance on them indexes learning ability only if the assumption of equivalence of opportunity is valid.

An alternative way to measure learning ability is that of observing the performance of children on tasks that themselves principally demand learning rather than the recall of what has been learned in the past. The strength of this alternative is that the assumption of equivalent previous opportunities for learning is unnecessary. Its weakness is that any single learning task must necessarily be quite specific and not representative of the wide range of learning activities demanded in school. It is precisely this weakness of direct measures of learning proficiency that constitutes the strength of the standardized test. Such tests do sample from a broad range of the kinds of demands made by school learning tasks and performance on these tests has been shown to be a relatively accurate indicator of school success. Clearly the conclusion must be that, as yet, it is not warranted to recommend the replacement of standardized tests of what has been learned by learning tasks that directly measure learning proficiency. Nevertheless, learning tasks can be used to test explanations of differences in performance on widely-used measures of intelligence and achievement.

The simplest hypothesis to explain strata discrepancies in school learning is that of underlying differences in learning ability. If the hypothesis is correct, children who perform poorly on tests of school achievement should also perform poorly on tasks that demand new learning. The second hypothesis is more complicated. It asserts initially that children may perform poorly on standardized tests for at least two reasons. The first is that they have relatively low learning ability. The second is that, because of limited opportunity they did not learn initially what the tests demand that they recall. If the latter is true of a child, then he should perform proficiently on a learning task even though his score on a standardized test is low. Should this combination of outcomes result, the implication is that the child's standardized test scores underestimate his learning ability. On the other hand, what is the implication if a child performs poorly on both standardized tests and on learning tasks? The most obvious inference is that he is a slow learner. But the concern of the present project with the role of elaboration in learning efficiency suggests an alternative inference, namely, that two different kinds of children will be found to score low on both standardized tests and on learning tasks. One kind of child is the true slow learner whose native intellectual endowment does in fact limit his ability to learn. The other kind of child is one whose previous experience has not only deprived him of the opportunity to learn the relevant information that must be recalled in order to answer standardized test questions but also of the opportunity to learn how to learn. That is, he has not acquired the propensity to elaborate what he is asked to learn and, therefore, does not learn efficiently.

In the research to be reported, three kinds of experimental attempts were made to clarify the facts with regard to these matters. The first was designed to compare the learning proficiency of low-strata children with that of high-strata children under virtually optimal conditions of learning and under conditions of elaboration known to facilitate learning in upper-strata children. The second experiment was designed to explore the role of individual differences in the efficacy of elaboration for upper- and lower-strata children. And the third experiment was designed to explore the effects of less than optimal learning conditions on the relative performance of lower- and upper-strata children.

Experimental Studies

The plan of presenting the remainder of the report is to describe the methods and results of the several experiments performed. A brief introduction will precede, and a brief discussion will follow, the descriptions of each of the studies. The present section is divided into two main parts, consistent with the format initiated in the general introduction: elaborative facilitation; and, elaboration and learning proficiency.

Elaborative Facilitation

Experiments to be reported in this section are concerned with evaluating empirically explanations of the facilitory effect of verbal contexts on the learning of constituent noun pairs and with exploring the possibility of detecting parallel effects attributable to visual factors.

Experiment I: The Hypothesis of Intralist Similarity

One of the first explanations suggested in the wake created by the results of the experiment reported by Rohwer (33) was in terms of intralist similarity. Recall the critical features of that study. Sixth-grade Ss were asked to learn eight noun pairs presented during the pretraining trial in the context of a meaningful, grammatical verbal string. The three experimental conditions were distinguished by the form class of the word in each of the contextual strings that connected the two noun phrases: conjunction vs.

preposition vs. verb. In all respects other than that of connective form class, the three kinds of strings were identical. The results were that more correct responses were produced in the verb and preposition conditions than in the conjunction.

The problem is to account for the fact that verb and preposition string elaboration was facilitory while conjunction string elaboration was not. An examination of the contextual strings presented in the three conditions suggested one hypothesis. The number of different words used as connectives in the set of eight strings varied across the form-class conditions; only two words (and, or) served in the conjunction strings whereas six and eight different words served respectively in the preposition and verb strings. In this respect the construction of the three kinds of strings followed the natural language in which there are very few coordinate conjunctions, a slightly larger number of prepositions and many verbs. At any rate, the result of this manner of composing the contextual strings was that the amount of formal similarity within each of the sets of eight strings varied with the form class of the connective. It has been shown that as the amount of intralist stimulus similarity increases, the difficulty of learning the list also increases, presumably because of a corresponding increase in the amount of intralist interference produced (1, 39, 40). Thus, if the contextual strings in each of the conditions served as the stimuli for the required responses, namely, the second nouns from each of the strings, the result observed by Rohwer (33) is attributable to differences in intralist similarity. The present experiment was designed to test this hypothesis by manipulating independently the variables of connective form class and inter-string similarity.

Method

Materials and design. Two lists of pairs of high-frequency nouns formed the paired-associate learning task for all Ss. Each pair of nouns was presented in a meaningful, grammatical string of seven words; except for variations in connectives, the strings were the same as those used by Rohwer (33). The various conditions were distinguished by the form class of the connectives (conjunction vs. preposition vs. verb) and the number of different connectives (two vs. four.vs. eight) in the strings. The strings for the verb-four condition, for example, were those used in verb-eight except that only four of the original verbs were selected and each appeared in two strings. It was not possible to balance the design completely since only two appropriate coordinate conjunctions are available in English. The entire experiment, then, consisted of a 2 x 3 factorial (prepositions vs. verbs; and, two vs. four vs. eight) and an additional condition in which the connectives were two coordinate conjunctions. The hypothesis implied by the similarity interpretation asserted that differences in learning rate would be associated with variations in the number of different connectives and not with differences in the form class of the connectives.

A 2 x 2 transparency was made of each of the strings and of each of the stimulus nouns so that both the study and the test materials were presented by means of a slide projector with an attached timer. Subjects recorded their responses in booklets, one response per page. Each page of the response booklets was numbered and bore only a horizontal line of sufficient length to accommodate a written response noun.

Subjects. The sample of 112 children was drawn from the sixth-grade population of two local elementary schools known to be comparable with respect to neighborhoods served, socioeconomic status and tested intelligence. Within each school, eight children were randomly assigned to each of the seven experimental conditions and four of the eight were randomly selected to receive one of the lists and the remaining four received the other.

Procedure. The task was administered to groups of four Ss simultaneously. After Ss were seated in the testing room, the response booklets were distributed and the instructions were read. The Ss were told that they would be asked to learn pairs of nouns in such a way that when shown the first noun of a pair, they could supply the second. It was explained that the nouns would be presented in the context of a phrase or a sentence that was intended to aid in the learning of the pairs. A sample string and its constituent stimulus noun were then presented successively to illustrate the experimental procedure. The paired nouns in each string were typed in capital letters and underlined to avoid confusion.

The task itself was administered in a study-trial, test-trial manner for a total of three complete learning trials. The strings were presented at a 4-sec. rate and each was read aloud by the E as it was shown. The stimulus nouns were presented at a 4-sec. rate and were also read aloud by the E as they appeared on the screen. Different orders of presentation were used on each study trial and on each test trial.

Results and Discussion

Learning. Learning was measured in terms of the total numbers of correct responses emitted on the three test trials. The results are presented in Table 1. An analysis of variance was performed in which the principal factors were Schools, Lists, Trials and Treatments (Appendix A-1). Since the factor of Schools was not significant, $F<1$, the data from the two schools were pooled for all remaining tests. The variance associated with Treatments was partitioned in a manner suggested by Winer (45, p. 263), so that the following sources were assessed: Conjunction-Two condition vs. all other conditions; Form-Class (Preposition vs. Verb);

Table 1
Mean Numbers of Correct Responses and
Mean Percentages of Intralist Intrusions as a
Function of Form Class and Intralist Similarity

		Form Class		
Dependent Measure	Intralist Similarity	Conjunction	Preposition	Verb
Correct Responses	2	12.31	17.88	17.56
	4		17.38	16.50
	8		17.31	17.31
Intralist Intrusions	2	20.3	10.4	6.6
	4		12.6	13.1
	8		10.9	7.2

Intralist Similarity (Two vs. Four vs. Eight); and, the interaction Form Class x Intralist Similarity. Only two significant sources of variation emerged in the entire analysis. Trials were, of course, significant, $\underline{F}\ (2,196) = 172.64$, $\underline{p} < .01$.[1] The effect of the treatments was located entirely in the contrast between the Conjunction-Two condition and the rest of the design, $\underline{F}\ (1,98) = 12.54$, $\underline{p} < .01$. That is, the variance associated with differences in intralist similarity, with the difference between prepositions and verbs, and with the interaction of these factors was negligible, $\underline{F} < 1$, in all cases. Remarkably, the amount of facilitation produced by prepositions and verbs remained the same regardless of the number of different words used as connectives. Since variations in the similarity of verbal strings made no difference in the amount learned and since prepositions and verbs produced more correct responses than conjunctions, even when equated for intralist similarity, the present results disconfirm the hypothesis that form-class differences should be attributed to differential intralist similarity.

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[1] The decision rule followed in all statistical tests performed on data from the present project was to reject the null hypothesis with $\underline{p} \leq .05$. Other levels of significance are reported throughout only to provide descriptive information to the reader.

Errors. Since the effect of high degrees of intralist similarity should be to produce substantial intralist interference, the rate of intralist intrusions in the seven experimental conditions was examined. For each S a score was calculated representing the ratio of the number of intralist intrusions he emitted to the total number of overt responses he made. The results are presented in Table 1. An arcsin transformation was applied to these scores and they were assessed by means of analysis of variance (Appendix A-2). Once again, the only significant source of variation was the contrast between the Conjunction-Two condition and all other groups, $F\ (1,98) = 7.04$, $p < .01$. The magnitude of all other treatment effects was negligible, all $Fs < 1$. Variations in intralist similarity did not produce differences in the rate of intralist intrusions but, in terms of this measure, the amount of intralist interference produced by the conjunction strings was higher than that produced by the preposition and verb strings matched for numbers of common connectives.

This result leads to the speculation that the effective source of intralist similarity may be located in mediate stimuli rather than in the stimulus materials presented to the Ss. It is possible to conceive that the verbal strings evoke mediate responses which, in their role as stimuli, may bear similarity relations to one another that are different than those among the overt stimulus materials.

It should be noted that the results of the present experiment are critical for virtually all of the other studies to be reported. The clear rejection of the intralist similarity hypothesis warrants the assumption that the different numbers of connective words in conjunction and verb strings are irrelevant to the differences in amount of learning observed. Therefore, the practice of following the natural language in the construction of contextual strings was continued in all subsequent experiments.

Experiment II: The Hypothesis of Semantic Constraint

Having disposed of the most straightforward available explanation of the form-class effect, attention turned to an alternative, namely, that suggested by Rohwer in an interpretation of the results of his experiment (33). The interpretation was made in terms of semantic constraint.

It was reasoned that verbs impose narrower limits on subsequent nouns in a string than do prepositions and that prepositions impose narrower limits than conjunctions. If so, the class of appropriate response nouns is smaller when the connective is a preposition than when it is a conjunction and still smaller when the connective is a verb. Finally, it was assumed that the probability of selecting a correct response for a given stimulus noun increases as the size of the class of appropriate response nouns decreases. From these assumptions the prediction followed that the presentation of paired nouns in the context of verbal strings would produce faster learning when the connective was a verb than when it was a preposition and that a preposition connective would produce faster learning than a conjunction.

The present experiment was designed to evaluate this constraint explanation by testing one of its implications for paired-associate learning. The materials were constructed to permit independent manipulation of the form class of connectives and the size of the class of response nouns. We expected that, if the size of the response classes was equated, the presentation of paired nouns connected by a conjunction would produce a rate of learning as fast as that produced by the presentation of the same nouns connected by a verb.

Method

Materials and design. All Ss were given the same task: to learn a list of 20 pairs of high-frequency nouns. Each pair was presented in the context of a meaningful, syntactically structured verbal string. Two sets of verbal strings were constructed: in one of these the form class of the connectives was conjunction; and, in the other the form class was verb. With the exception of the two connectives, the strings comprising the two sets were identical.

Each set of strings was subdivided into two mutually exclusive subsets of 10 strings each according to the rule that all response nouns within one subset would be semantically appropriate for every string in the subset and semantically inappropriate for all strings in the other subset. Thus, the 10 nouns within each subset were completely interchangeable. This rule, of course, only applies to the verb strings since conjunction connectives provide no semantic information about subsequent nouns. All of the response nouns in one subset (List A) were names of animate objects capable of autonomous locomotion. All of the response nouns in the other subset were names of objects incapable of autonomous locomotion (List B). The verb strings were constructed first and the conjunction strings were formed by substituting a coordinate conjunction (and, or) for each of the verbs. A complete list of the study-trial materials may be found in Table 2.

The size of the class of response nouns was manipulated by varying the conditions of response mode. Half of the Ss were asked to recall each response noun when presented with the appropriate stimulus noun and the other half were asked to recognize the appropriate response noun in a list of ten of the response nouns used in the experiment. The recall condition was essentially similar to the learning task in which the differences between the effects of conjunctions and verbs was initially detected. The constraint hypothesis asserts that under this condition the size of the response class, given verb strings, is substantially smaller than

Table 2
Study-Trial Materials: Conjunction and Verb Strings

List A

Conjunction	Verb
The BEE and a DOG.	The BEE chases a DOG.
A LION and the HORSE.	A LION scares the HORSE.
The STICK or the COW.	The STICK hurts the COW.
A TRAIN and a CAT.	A TRAIN kills a CAT.
The ANT or a MOUSE.	The ANT bites a MOUSE.
A HUNTER and the SHEEP.	A HUNTER calls the SHEEP.
The FUR or the DEER.	The FUR covers the DEER.
The LIGHTNING or the GOAT.	The LIGHTNING surprises the GOAT.
A MAN or the FOX.	A MAN helps the FOX.
An AIRPLANE and a PIG.	An AIRPLANE wakes a PIG.

List B

A SPIDER and a POLE.	A SPIDER climbs a POLE.
A WORKER or the STAIRS.	A WORKER paints the STAIRS.
A KNIFE and the SHIP.	A KNIFE carves the SHIP.
The STORM or a CHAIR.	The STORM breaks a CHAIR.
The GLUE or the LADDER.	The GLUE fixes the LADDER.
A BIRD or the FENCE.	A BIRD uses the FENCE.
The ICE and a SIGN.	The ICE cracks a SIGN.
The NAIL and a ROPE.	The NAIL holds a ROPE.
The PENCIL or a ROCK.	The PENCIL marks a ROCK.
The BROOM and a WALL.	The BROOM sweeps the WALL.

that for conjunction strings. In contrast, the recognition condition was designed to equate the sizes of the response classes for both the conjunction and verb strings. This was done by presenting Ss in both the conjunction and verb groups with identical lists of 10 alternative response nouns for each stimulus noun presented. All 10 of the alternative nouns were semantically appropriate for the string in which the given stimulus noun was originally presented. For example, whenever a stimulus noun that had been paired with a response noun from the first subset was presented, the list of response alternatives consisted of the entire first subset. Thus, the verb strings provided no more semantic information as to which of the 10 response nouns was correct than did the conjunction strings. For the conjunction condition, these materials consisted of 20 2 x 2-in. transparencies bearing the 20 paired associates in the context of conjunction strings. Similarly, the materials for the verb condition consisted of 20 transparencies bearing the paired nouns in the context of verb strings.

In summary, a 2 x 2 factorial design was used in which the first factor was Form Class (Conjunction vs. Verb) and the second was Response Mode (Recall vs. Recognition). The prediction that followed from the constraint hypothesis was that verb strings would produce substantially more efficient learning than the conjunction strings only in the recall conditions, not in the recognition conditions.

Subjects. The total sample consisted of 60 sixth-grade children drawn from two local elementary schools, 40 children from one school and 20 from the other. Within each school, Ss were assigned randomly to the four experimental groups; each group was comprised of 15 Ss, 10 from one school and 5 from the other.

Procedure. The task was administered by means of a study-trial, test-trial method in which all Ss were given a total of two study and two test trials. This method permitted the testing of 5 Ss simultaneously. The study-trial materials were identical for both Response Mode conditions and varied only with respect to the Form Class factor. The conditions of response differed according to the character of the response booklets used: Each response sheet for the recall condition simply bore a horizontal line on which the S was asked to write his response; in contrast, each response sheet for the recognition condition bore a list of 10 alternative response nouns below which appeared the horizontal line on which the S was asked to write his chosen response. The stimulus words were projected successively on the screen and were identical for all four experimental conditions.

When Ss entered the testing room, they were given response booklets for Trial 1 and the task was described to them. They were asked to memorize the 20 pairs of words in such a way that they could supply the second noun in each pair when shown the first. The procedure of presenting the pairs in the context of sentences or phrases was described and it was suggested that this might increase their ability to learn. Both the study trial and the test trial were illustrated by two examples in which two sample strings were presented followed by the presentation of the stimulus noun from each string. The first study trial then began with the projection of each slide at a 4-sec. rate. The E read each string aloud as it appeared on the screen. After the last string had been shown, the Ss were told to open their response booklets to the first page, look at the stimulus noun, and write their response in the space provided. The stimulus nouns were presented at a 15-sec. rate to permit the Ss sufficient time to select their responses, write them in the booklet, and turn the page in preparation for the next stimulus. As each stimulus was projected, it was read aloud by E.

At the end of the first test trial the response booklets were collected and those for Trial 2 were distributed. The procedure followed in Trial 1 was repeated to the completion of Trial 2 except that the strings and the stimulus nouns were presented in an order different from that used in Trial 1.

Results

Learning was measured in terms of the number of correct responses emitted during the two test trials. The mean numbers of correct responses for each of the four experimental conditions are presented in Table 3. These results were assessed by means of analysis of variance (See Appendix B-1) which revealed significant main effects associated with Form Class, F (1,56) = 10.51, $p < .01$, Response Mode, F (1,56) = 14.17, $p < .01$, and Trials, F (1,56) = 242.93, $p < .01$. The interaction crucial for the constraint hypothesis was not significant, $F < 1$, nor were any of the remaining tests in the analysis of variance. Verb strings produced substantially more efficient learning than did conjunction strings and the recognition mode produced more correct responses than did the recall mode, as expected. Even though the interaction of principal interest was not statistically significant, the difference between verb and conjunction strings appeared smaller under conditions of recognition than under conditions of recall as predicted by the constraint hypothesis. Given this, it was decided to replicate the experiment.

Table 3
Mean Numbers of Correct Responses as a Function of Form Class and Response Mode (Original Experiment)

	Form Class	
Response Mode	Conjunction	Verb
Recall	13.60	21.47
Recognition	22.47	27.00

In the first replication, the design was augmented by an additional condition of Response Mode. Furthermore, the experiment was performed on both a sixth-grade sample and a fifth-grade sample of children.

The additional experimental groups were added to provide a corollary test of the constraint hypothesis. Suppose it were shown that under the original recognition condition, the difference between verb and conjunction strings could be significantly reduced. Such a result would be consistent with the constraint hypothesis but it would be open to an alternative interpretation, namely, that some characteristic peculiar to the recognition procedure itself prevents the detection of a difference. For example, it has been shown repeatedly that performance measured in terms of recognition yields higher estimates of the amount learned or retained than when recall is required (30). Thus it might be that differences at high levels of performance are not comparable to differences at lower levels of performance. In order to clarify the interpretation of such results, a second recognition condition was added. In this case, however, the condition was designed to permit semantic constraint to operate and to produce again a difference between the conjunction and verb conditions.

The second recognition condition (Recognition 10/5) differed from the first (Recognition 10/10) only in the composition of the lists of response alternatives offered for each stimulus noun. In the Recognition 10/10 condition, all of the response alternatives were appropriate for both the conjunction strings and for the verb strings. In the 10/5 condition, however, the 10 alternative response nouns were chosen so that only five would be semantically appropriate for the verb condition while all 10 were appropriate for the conjunction condition. Thus, the prediction from the constraint hypothesis was that verb strings would produce more efficient learning in the 10/5 condition than the conjunction strings but not in the 10/10 condition.

Method

Materials and design. The task and the materials for the replication were the same as those for the original experiment. The only exception was the composition of the response sheets for the 10/5 group. In the 10/10 condition, the 10 alternative responses for each stimulus noun were drawn from the same subset to insure that all would be semantically appropriate. In the 10/5 condition, the 10 response nouns consisted of five from one subset, the subset containing the correct response, and five from the other, inappropriate subset. For example, if the correct response noun were a member of the animate subset, five of the response alternatives were the names of animate objects and the other five were names of inanimate objects. The members of the two subsets were randomly ordered on each response sheet such that no clear grouping was apparent.

It was necessary to divide this experiment into two distinct 2 x 2 designs since the simultaneous analysis of all six experimental conditions involved the confounding of two factors: the mode of response (Recognition vs. Recall) and, within the recognition conditions, the semantic appropriateness of the alternative responses (Conjunction vs. Verb strings).

The first design was a replication with the addition of two classificatory factors used to increase experimental precision. In all, five factors were involved: Form Class (Conjunction strings vs. Verb strings); Response Mode (Recall vs. Recognition 10/10); Grades (Fifth vs. Sixth); Reading Ability Levels (High vs. Medium-High vs. Medium-Low vs. Low); Trials (1 vs. 2). Performance scores from a standardized reading test, the Stanford Achievement Test, were available on all Ss and this information was used to implement a levels design. The experimental prediction of principal concern was that the verb strings would produce more efficient learning than the conjunction strings in the recall but not in the recognition condition.

With one exception, the second design was the same as the first. The Response Mode factor involved a comparison of the Recognition 10/10 condition with the Recognition 10/5 condition. Thus the experimental groups in the Recognition 10/10 condition were involved in both analyses. For the second analysis the prediction consistent with the constraint hypothesis was that verb strings would produce faster learning than the conjunction strings in the Recognition 10/5 condition but not in the Recognition 10/10 condition.

Subjects. The total sample consisted of 48 sixth- and 48 fifth-grade children drawn from a local elementary school populated generally by homogeneously bright students who come from middle- and upper-middle class homes. Within each grade, Ss were ordered with respect to reading achievement scores and then divided into quartiles of 12 Ss each. Two Ss selected at random from each quartile were randomly assigned to each of the six experimental groups. Each group was assigned eight Ss from each of the two grades.

Procedure. The procedures followed were the same as those followed in the initial study. The task was administered by a study-trial test-trial method and Ss were tested in groups of eight. A 4-sec. presentation rate was used during the two study trials and a 15-sec. rate was used during the two test trials. The E again read the strings aloud to Ss as they appeared on the screen during the study trials and read the stimulus words aloud as they appeared on the screen during the test trials.

Results

As in the original experiment the dependent variable in the present one was the number of correct responses emitted. The results are presented in Table 4.

Design 1. An analysis of variance was performed on the data produced by the Recall and Recognition 10/10 groups (See Appendix B-2). The main effect for levels of reading ability was not significant, F (3,31) = 1.59, $p > .05$, nor were any of the interactions with levels, nor was the main effect for grades, F (1,31) = 4.13, $p > .05$. The main effect for trials was significant, F (1,31) = 258.82, $p < .01$, but none of the interactions of other factors with

Table 4

Mean Numbers of Correct Responses as a Function of Form Class, Response Mode, and Grade (Replication I)

		Form Class	
Grade	Response Mode	Conjunction	Verb
5	Recall	14.63	20.63
	Recognition 10/10	19.00	30.88
	Recognition 10/5	21.00	30.63
6	Recall	13.75	28.00
	Recognition 10/10	24.12	29.38
	Recognition 10/5	19.75	32.25

trials was significant.

The factors of principal interest produced notably large effects. Response Mode differences favoring the Recognition 10/10 conditions were significant, $\underline{F}$ (1,31) = 28.02, $\underline{p} < .01$, and Form Class differences favoring the verb conditions were significant, $\underline{F}$ (1,31) = 56.26, $\underline{p} < .01$. But the interaction of Response Mode x Form Class, predicted by the constraint hypothesis, was not significant, $\underline{F} < 1$. A higher-order interaction, however, required a reinterpretation of these effects: The interaction of Grades x Response Mode x Form Class was significant, $\underline{F}$ (1,31) = 8.91, $\underline{p} < .01$. The form of the interaction was such that the prediction derived from the constraint hypothesis was confirmed by the performance of the sixth-grade Ss and contradicted by the performance of the fifth-grade Ss. That is to say, the predicted interaction of Response Mode x Form Class was significant in the sixth-grade samples, $\underline{F}$ (1,31) = 6.52, $\underline{p} < .05$, but not in the fifth-grade samples, $\underline{F}$ (1,31) = 2.78, $\underline{p} > .05$. Furthermore, the direction of this second-order interaction in the sixth-grade was opposite that in the fifth-grade. In the sixth-grade groups, the verb strings produced more efficient learning than the conjunction strings only for the Recall conditions and not for the Recognition 10/10 conditions. In contrast, the difference between conjunction and verb strings for the fifth-grade Ss was larger under the Recognition 10/10 condition than under the Recall condition. In sum, the constraint hypothesis was firmly supported by the results in the higher grade and just as firmly denied by the results produced by the younger children.

Design 2. In the analysis of variance performed on the data produced by the Recognition 10/10 and Recognition 10/5 conditions, (See Appendix B-3), only two significant sources of variation emerged: Form Class, F (1,30) = 53.55, $p < .01$; and Trials, F (1,30) = 173.21, $p < .01$. Neither of the two interactions that might have provided support for the constraint hypothesis reached statistical significance. The interaction of Response Mode x Form Class was not significant, F (1,30) = 1.19, $p > .05$, nor was that of Grades x Response Mode x Form Class, F (1,30) = 3.64, $p > .05$, although the latter was relatively substantial. The simple effects of the interaction of Response Mode x Form Class was significant for Grade 6, F (1,30) = 4.50, $p < .05$, but not for grade 5, $F < 1$. The latter result is, of course, consistent with the results reported in connection with Design 1, but nevertheless, provides only weak support (confined to the sixth-grade sample at that) for the constraint hypothesis.

No prediction relevant to this outcome had been made in advance and no convincing explanation could be developed post hoc. Before making a serious attempt to interpret the striking differences detected in Design 1 between fifth- and sixth-grade children, it was decided to replicate the entire experiment on other samples of fifth- and sixth-grade children drawn from a comparable population.

The second replication differed from the first in only two ways: the classification factor of reading ability levels was not used since it had proved of little consequence in the previous experiment; and, the 96 Ss were drawn from a school in another district because the population of fifth- and sixth-grade children in the district initially chosen had been virtually exhausted by the first two experiments. The school sampled in the present experiment was selected specifically because of its close comparability with the school previously sampled with respect to the tested intelligence and the social-class membership of its students. Apart from these two deviations, the second replication was identical with the first.

Results

Once again the dependent variable was the numbers of correct responses emitted on Trials 1 and 2. The results are shown in Table 5.

Design 1. A four-way analysis of variance was performed in which the principal sources of variance were: Grades (Fifth vs. Sixth); Response Mode (Recall vs. Recognition 10/10); Form Class (Conjunction vs. Verb); and Trials (1 vs. 2) (See Appendix B-4). The main effects for Grades and for Response Mode were not significant, $F < 1$, in both cases. The result for Grades is consistent with that found in the school used in the first replication but the result for Response Mode is radically different. We have no explanation for the fact that the recognition conditions produced no more efficient learning than the recall in the present experiment.

Table 5
Mean Numbers of Correct Responses as a Function of Form Class, Response Mode, and Grade (Replication II)

		Form Class	
Grade	Response Mode	Conjunction	Verb
5	Recall	16.88	25.25
	Recognition 10/10	19.63	26.63
	Recognition 10/5	20.50	28.75
6	Recall	18.63	30.13
	Recognition 10/10	16.25	31.25
	Recognition 10/5	17.50	26.75

The main effect for Form Class was once again significant, $\underline{F}$ (1,56) = 41.20, $\underline{p} < .01$, and by itself accounted for more than 25 percent of the total variation observed. Clearly, the two different kinds of connectives produce reliably and substantially different rates of learning.

The only remaining effect of statistical significance was Trials, $\underline{F}$ (1,56) = 230.63, $\underline{p} < .01$; none of the interactions were significant sources of variance. The two interactions of principal interest in view of the results obtained previously, Response Mode x Form Class, and Grades x Response Mode x Form Class, each accounted for less than 1 percent of the total variation and produced $\underline{F}$ ratios smaller than 1. The conclusion from these results is clear: The constraint hypothesis finds no support whatever in the performance of these Ss.

Design 2. The results of the analysis of variance performed on the data contained in Design 2 were entirely consistent with those reported in connection with the first replication (See Appendix B-5). The only significant effects were those associated with: Form Class, $\underline{F}$ (1,56) = 37.57, $\underline{p} < .01$; and Trials, $\underline{F}$ (1,56) = 176.51, $\underline{p} < .01$. The main effects of Grades and Response Mode each produced an $\underline{F} < 1$, as did the interaction of Grades x Response Mode x Form Class. The interaction of Response Mode x Form Class also accounted for an inconsequential portion of the total variation, 1 percent, $\underline{F}$ (1,56) = 1.18, $\underline{p} > .05$. Again, the results afford no evidential support for the constraint hypothesis.

Discussion

The hypothesis of semantic constraint is not sufficient to explain the facilitation of learning produced by verb connectives. In only one of the times that the basic experimental design was repeated did the results lend support to the constraint explanation. Even when the size of the class of appropriate responses was equated for conjunction and verb conditions, verb strings produced substantially faster learning. Thus, the phenomenon remains to be explained.

Before dismissing the notion of semantic constraint, one of its hidden assumptions should be exposed and examined. For clarity, the learning process may be divided into an input phase, corresponding to the study trial in the present experiment, and an output phase, corresponding to the test trial. Semantic constraint, as presently formulated, should have its effect on performance during the output phase, that is, when S selects a response from among those available to him. It is at the time of recall that the verb might semantically limit the number of alternatives from which a response must be chosen. This may be an erroneous assumption. The principal locus of the effect of verb strings on learning may be the input phase rather than the output phase, just as variations in the accuracy of recall can be localized in the phase of original learning rather than in the conditions of recall (24). If this analysis were verified empirically, it would suggest that explanations of the facilitory effect of verb strings should refer to conditions which affect the acquisition process during the phase of initial input.

Two other features of the present results deserve special emphasis. The first concerns the power of verb strings to produce high levels of performance. In each of the experiments performed, the presentation of the paired associates in verb strings was sufficient to produce performance under conditions of recall that was as efficient as that produced by conjunction strings under conditions of recognition. Practically speaking, verb connectives can reduce the difficulty of a recall task to that of a normal recognition task. This may rightly be construed as a demonstration of the commonplace that the manner in which learning materials are presented to the learner, or the manner in which he operates on them, markedly affects learning efficiency.

Finally, the results of repeated replication of the same basic design in the present effort demonstrate another commonplace, namely, the too infrequently considered caution that a single experiment is not sufficient to extablish a phenomenon nor to decide an issue. Had the present design been performed only once, on the sixth-grade sample in the first replication, the conclusion implied about the constraint hypothesis would have been diametrically different from that which is now strongly indicated.

Experiment III: Sentence Elaboration and Serial Learning

Clearly, the form-class effect in PA learning does not yield easily to explanatory attempts nor does the general phenomenon of sentential elaboration. The implication is that protracted effort will be required to understand the processes involved. In view of this, it is well to inquire as to the generality of elaborative facilitation across different kinds of learning tasks and as to the generality of the form-class effect. One of the purposes of the present experiment was to permit an assessment of the first of these two varieties of generality, that is, to determine whether or not sentential elaboration can facilitate serial as well as PA learning. A second purpose was to contribute to an explication of the theoretical question of what is learned in serial learning.

Recently, considerable attention has focused on the question whether or not identical processes are involved in learning the serial order of items in a list and in learning the pair-wise arrangement of items in a list. The most frequently used method in attempts to answer this question has been that of transfer designs, either serial (Ser) to paired associate (PA) or PA to Ser. Although evidence thus far produced by the application of this method is not yet entirely conclusive, some investigators have construed available results as implying that the processes of Ser and PA learning do indeed differ. Jensen (11), for example, has contended that the learning of a Ser list consists of the integration of a sequence of responses into a single unit rather than of the acquisition of connections between successive eliciting stimuli and their companion responses. Adopting this contention (15), Jensen and Rohwer (16), have gone on to characterize one of the differences between Ser and PA learning in terms of the relative importance of past verbal experience for the two kinds of learning: "In short, we hypothesize that PA learning ability reflects relatively more the richness of the S's past verbal experience and its spontaneous availability in a learning situation, while serial learning constitutes a more fundamental kind of ability which is relatively unaffected by the amount of previous verbal experience (16, p. 602)."

The purpose of the present experiment is to disentangle the hypothesis of response integration as a description of Ser learning and the assertion that the availability of previous verbal experience is irrelevant to the efficiency of Ser learning. The validity of the latter hypothesis depends, in part, on the results of a study (16) conducted to test one of its implications, namely, that verbal organization of PA items should facilitate acquisition whereas verbal organization of Ser items should not. Recall that the treatment condition for the Ser task required the S to elaborate the names of each successive pair of objects into a sentence, two items per sentence. This procedure is consistent with the conception that Ser learning consists of the acquisition of connections between successive items each of which serves both as a stimulus and as a response.

The results for elementary school children replicated those previously obtained for mentally retarded adults (13); The sentence condition produced substantial facilitation of PA but not of

Ser learning. Accordingly, the investigators concluded in favor of their original hypothesis regarding the irrelevance of verbal organization for Ser learning and went on to say: "If a true difference between the sentence and naming conditions were found to exist, we would be inclined to interpret the difference as being attributable to facilitation of response learning rather than to facilitation of serial learning *per se* (p. 606)."

In contrast to these conclusions, the guiding hypothesis for the present study is that verbal organization is relevant to Ser learning but only if the type of organization imposed is consistent with what is ordinarily learned when a Ser list is acquired. In agreement with Jensen (11) and with Jensen and Rohwer (15) it is assumed that the learning of a Ser list consists of the process of integrating the items into a single response. On this assumption, the absence of facilitation previously reported (13, 16) would be expected; the kind of verbal organization used, that is, successive discrete sentences, is not consistent with what is presumably acquired in Ser learning. A different type of verbal organization, specifically, one that confers on all items in the Ser list membership in a single unit, would be expected to produce facilitation not accountable in terms of enhanced response learning. The present experiment was designed to test this prediction.

Method

Materials and design. All *S*s were given a common task, namely, to learn the serial order of one or the other of two lists of fourteen familiar nouns. The design was a 6 x 2 x 2 x 4 factorial in which the factors were, respectively: conditions, lists, grades, and trials. The various conditions differed only with regard to the character of the one study trial during which the list was first presented; thereafter all were identical.

The six conditions may be viewed as an aggregation of an experimental and five control groups. The study-trial materials for the experimental or single sentence (SS) condition were constructed to conform with the requirement that all of the items in the list be contained within the same verbal unit. Each of the fourteen nouns was presented in the context of a three- or four-word phrase. The critical property of the phrases was that when read in the prescribed order, they formed one continuous, meaningful sentence. Thus the study-trial materials for the SS condition were conceived to be a concrete expression of a verbal organization consistent with the interpretation of serial learning as a process of integrating a single response.

In order to answer the question of central interest, that is, whether or not SS would facilitate Ser learning, a noun control (NC) condition was used. The study-trial materials for NC simply consisted of the fourteen nouns in the list presented successively in accord with the traditional Ser procedure.

Since it was expected that learning would be more efficient in SS than in NC, an additional condition was necessary to permit an evaluation of an alternative interpretation of whatever facilitation was observed. Following Jensen and Rohwer (16) it might be argued that the verbal context in SS would affect response learning rather than the integration of the list as a unit. If so, it can be reasoned that the same effect would be produced by the presentation of each noun in the context of a phrase even when the phrases are independent of one another such that their seriation does not form a continuous sentence. Accordingly, in the phrase control (PC) condition, the study-trial materials consisted of a set of fourteen unrelated phrases, one for each of the nouns in the list. The PC condition served the added function of providing a comparison with SS in which noun study-time was equated, as was not the case with NC.

As a control for response learning, however, PC by itself was not entirely adequate since the particular words used in the verbal contexts were necessarily different than those used in SS. By way of obviating this difficulty, the same phrases used in SS were presented in a scrambled order in the scrambled sentence control (SSC) condition such that their succession did not form a sentence.

Note that although all of the words presented in SSC were identical with those in SS, the order of items in the list varied. Thus in order to evaluate directly the effects of SSC on serial learning, the remaining conditions in the design were simply scrambled versions of NC (SNC) and PC (SPC) where the order of the items in the list was the same as that in SSC. A complete set of the study-trial materials used for one of the lists is shown in Table 6.

The three remaining factors were: lists, grades and trials. Two distinct lists of nouns were used to reduce the risk that results would be specific to one set of items. Children were drawn from two grade levels rather than one only to provide a sample of adequate size, not to test hypotheses as to age differences.

Procedure. When S entered the room, E told him that he was to memorize a list of nouns (or nouns in phrases) in the order in which they were presented. The instructions described the procedures that would be followed in the study-trial and in the anticipation trials as well as the type and timing of the responses expected.

All materials were presented on a memory drum. Immediately after the instructions, the 14 successive nouns (or phrases) were shown at a 4-sec. rate and, as each one appeared, it was read aloud by E. Following the study-trial an asterisk appeared and S had four seconds to supply the first noun. The first noun appeared, and S had another four seconds to offer the second noun, and so on

Table 6
List A Materials

Single Sentence (SS)	Phrase Control (PC)	Noun Control (NC)
the grey CAT	the grey CAT	CAT
jumped over the LOG	we jumped the LOG	LOG
and crossed the STREET	I crossed the STREET	STREET
to find the BOWL	you find the BOWL	BOWL
of cold MILK	some cold MILK	MILK
under the CHAIR	his own CHAIR	CHAIR
in the new HOUSE	our nice new HOUSE	HOUSE
by the blue LAKE	a little blue LAKE	LAKE
where the young BOY	my fine young BOY	BOY
lost his left SHOE	he lost his SHOE	SHOE
while eating the FISH	she's eating the FISH	FISH
on the wooden BOAT	an old wooden BOAT	BOAT
during the STORM	that awful STORM	STORM
that came last YEAR	they came last YEAR	YEAR

Scrambled Sentence Control (SSC)	Scrambled Phrase Control (SPC)	Scrambled Noun Control (SNC)
that came last YEAR	they came last YEAR	YEAR
the grey CAT	the grey CAT	CAT
of cold MILK	some cold MILK	MILK
where the young BOY	my fine young BOY	BOY
and crossed the STREET	I crossed the STREET	STREET
on the wooden BOAT	an old wooden BOAT	BOAT
lost his left SHOE	he lost his SHOE	SHOE
to find the BOWL	you find the BOWL	BOWL
while eating the FISH	she's eating the FISH	FISH
jumped over the LOG	we jumped the LOG	LOG
in the new HOUSE	our nice new HOUSE	HOUSE
under the CHAIR	his own CHAIR	CHAIR
during the STORM	that awful STORM	STORM
by the blue LAKE	a little blue LAKE	LAKE

through the list to the end of the first anticipation trial. Three more anticipation trials were given for a total of four in all.

It is important to note that in all conditions, only the nouns themselves were presented during the four anticipation trials. In other words, *Ss* in the sentence and phrase conditions were given a verbal context only on the initial presentation trial.

Subjects. Ninety-six fourth- and fifth-grade children from a school serving a middle-class residential area participated in the experiment. Forty-eight children from each grade were randomly assigned to the six experimental conditions. All *Ss* were tested individually by the *E*.

Results

The dependent variable was the number of correct responses given by S over the four anticipation trials. A repeated measures analysis of variance was performed on the data. The analysis of variance table is presented in Appendix C-1. There were three significant sources of variation, namely, conditions, F (5,72) = 8.28, $p < .01$; trials, F (3,216) = 128.33, $p < .01$; and grades x trials, F (3,216) = 3.07, $p < .05$.

The trials effect was expected, and accounts for about 57 percent of the within variance. The grades x trials effect may be traced to the slightly superior learning rate of Ss in the fifth grade.

It is of particular interest that there is no main effect for either grades, $F < 1$, or lists, F (1,72) = 1.35, $p > .05$, and that none of the interactions involving these factors in the between portion of the table is significant. The mean number of correct responses per trial as a function of conditions and lists is presented in Table 7.

Table 7
Mean Numbers of Correct Responses
across Trials and on Trial 4

Lists	Conditions						
	SS	NC	PC	SSC	SNC	SPC	All
A	7.62	5.06	4.19	5.25	5.62	3.91	5.28
B	7.90	5.19	4.38	2.84	4.03	4.56	4.82
Across Trials	7.76	5.12	4.28	4.05	4.83	4.23	5.05
Trial 4	10.12	7.25	6.00	5.75	6.50	5.44	6.84

Within the main effect of conditions, Scheffé's method for post hoc comparisons reveals that the SS group differs from each of the other groups, and that no other pair-wise contrasts are significant. The sum of squares associated with the main effect of conditions accounts for 32.2 percent of the total between variability. The comparison, SS vs. the average of all the other conditions combined, accounts for 567.67 or 91.5 percent of the total between conditions sum of squares, 620.28. The sums of squares for all other available orthogonal comparisons is 52.61 which, with four degrees of freedom, is not significant. As an inspection of Table 7 indicates, the results are clear; SS did facilitate learning relative to the ordinary serial procedure condition, NC, and the magnitude of facilitation was as great on trial 4 as it was across trials. The additional fact that NC produced as many correct responses as each of the other control conditions contraindicates an interpretation of the facilitory effect of SS in terms of an enhancement of response learning.

Discussion

The results of the present study support the initiating hypothesis, namely that verbal organization is relevant to the integration of a sequentially ordered set of responses. Even though this conclusion is in direct opposition to that reached by Jensen and Rohwer (16) it is not inconsistent with their interpretation of serial learning as a process of response integration (15). Indeed, the present results may be construed as indirect evidence in support of that interpretation since the form of verbal organization employed follows from it.

A fruitful theory of what is learned in serial learning ought to have implications for the design of conditions to facilitate that process. The adequacy of the theory, then, depends, in part, upon whether or not the facilitative procedures that can be derived from it serve to increase learning efficiency. Although the present results are suggestive, they are not sufficient to permit a conclusive judgment in this regard. Accordingly, it is of some import to conduct a comparative experiment designed to assess the relative efficacy of facilitative conditions derived from the principal theories of serial learning.

The problem of the effect of SS on response learning deserves brief additional comment. In the present design, no provision was made for a direct assessment of the degree of response learning as a function of study-trial conditions. Nevertheless, it is difficult to discern in the SS phrases any properties relevant to the efficiency of response learning that are not also present in the PC phrases. Thus, our interpretation is that verbal organization of the appropriate type affects the process of serial learning directly.

Two other problems worthy of further investigation are suggested by the present results. The first concerns the effect of sentential organization on the form of the serial position curve. That is to say, it is pertinent now to examine in more detail the process of facilitating response integration as reflected in the numbers of items learned per trial and in the order in which they are learned. If the verbal context provided is critically involved in this process, variations in sentence properties such as phrase structure should affect the magnitude and location of errors in learning. Through the application of a phrase-structure analysis, Johnson (17) has achieved a remarkable degree of success in predicting the error frequencies in the learning of sentences as responses in a PA task. A similar application might prove fruitful in the case of serial learning.

Secondly, since it has been demonstrated that the provision of a verbal organization containing all of the items in a serial list facilitates learning, it is of interest to determine the conditions under which positive transfer would occur. One approach to this goal would involve the manipulation of both training and instructional variables relevant to the use and generation of verbal organization in the learning of serial lists. The effectiveness of the manipulations could then be evaluated in terms of performance on a transfer task administered in accord with the usual method of serial anticipation.

Finally, it is clear from these results that sentential elaboration can, indeed, facilitate Ser as well as PA learning. Questions concerning the generalizability of the form-class effect to Ser learning, however, still await experimental analysis. The next experiment reported is directed toward answering this kind of question not for Ser learning but for string learning.

Experiment IV: Connective Form Class and String Learning

Properties of verbal strings known to affect string learning have been shown to have both similar and dissimilar effects on the learning of noun constituents from such strings. Marks and Miller (19) found that grammatical English strings were easier to learn than scrambled English strings and, congruently, Rohwer (33) reported that the amount learned was greater when noun PAs were presented in the context of the former kinds of strings than when presented in the context of the latter. In the same experiment, however, Rohwer found no differences in PA learning associated with the grammaticality of contextual nonsense-word strings while, in contrast, Epstein (7, 8) has successfully demonstrated a facilitory effect of syntactic markers on the learning of nonsense-word strings.

The purpose of the present experiment was to determine whether or not a second variable, connective form class, known to affect the learning of constituent noun pairs also affects the learning of entire strings. Since the results of Experiments I and II suggest that properties inherent in connective form classes are responsible for differences in PA learning, it is of interest to inquire whether the variable has a similar effect in other learning tasks. In addition to providing information about the generality of the form-class effect, the present experiment was expected to produce results relevant to other suggested explanations of the effect in PA learning.

Method

Materials and design. The materials for all conditions were those used by Rohwer (33): two lists of eight verb strings and two lists of eight conjunction strings. Since preposition and verb strings have been shown to produce indistinguishable effects on PA learning, only the latter were used in the present study. The two kinds of strings were identical except for the form class of the connectives; all were seven words in length and of the form: article-adjective-noun-connective-article-adjective-noun. Each of the strings was photographed and mounted on a 2 x 2-in. slide transparency.

These materials were used in four different learning tasks. The first was a replication of two of the conditions in the PA experiment where the materials were originally administered: conjunction vs. verb. Subjects were asked to learn pairs of nouns, presented in the context of grammatical English strings, in such a way that the second noun could be recalled when the first was shown. (The two nouns in each string were printed in capital letters and underlined.) Even though the PA task was not germane to the principal purpose of the experiment, it was included to provide assurance that the connective difference previously observed could emerge under the somewhat divergent conditions of the present experiment.

Each of the three remaining tasks required that Ss engage in one or another variety of string learning. In order to locate more precisely the source of any observed failure of the form class effect to generalize to string learning, the tasks were chosen so as to depart progressively further from the PA learning paradigm itself. In the first (PA-CS), the initial instructions, the study-trial procedure and the materials were identical to those used in the PA condition. At the end of the first study trial, however, the conditions diverged, and, rather than simply recalling the response nouns, as they had been told to do, Ss in PA-CS were now asked to recall the entire remaining portion of each string when shown the constituent stimulus noun.

Although the formal difference between the PA task and PA-CS was minimal, it was anticipated that the change in task instructions between the study and test trials might, in itself, disrupt performance. Therefore, it was planned to give principle emphasis to the other two tasks in evaluating the generality of the form class effect.

In one task (CS-CS) cued string learning instructions were given and the task was indeed a cued string learning task. In the study-trial strings for the CS-CS conditions only the initial noun was typed in capitals and underlined. In the remaining condition (FS-FS) Ss received free string recall instructions and were asked to engage in free string recall during the test intervals. Neither of the nouns in the FS-FS condition was typed in capitals or underlined.

In summary, the principal portion of the design consisted of six independent groups where Connectives (conjunctions vs. verbs) were nested within three different tasks (PA-CS vs. CS-CS vs. FS-FS). The preliminary portion of the design (PA) was necessary to assess the viability of the connective difference in PA learning under the conditions of the present experiment.

Procedure. The tasks were administered by study-test methods to squads of six Ss each. At the beginning of the session all Ss were given three, eight-page booklets in which to record their responses during the three test trials. Each page was devoted to one and only one response and bore a horizontal line or lines indicative of the nature of the response required. For the PA conditions, a single horizontal line, of sufficient length to accommodate one word, appeared on the pages. For the PA-CS, CS-CS, and FS-FS conditions, each page bore seven horizontal lines, one for each of the words in the string to be recalled.

Apart from the instructions, the study-trial procedures were identical for all conditions. The slide transparencies were projected successively on a screen at a 4-sec. rate and, as the strings appeared on the screen, they were read aloud by the E. During the 4-sec. intertrial interval, Ss were reminded of the nature of their response task and were instructed to open their booklets to reveal the first response page.

The test-trial procedures varied across the four task conditions. In the PA condition, the test trials consisted of the successive presentation of the stimulus nouns at a 4-sec. rate. As each noun appeared on the screen, the E read it aloud, Ss recorded their responses and turned the pages of their booklets in preparation for the next item. Different orders of presentation were used on all study and test trials. In the PA-CS and CS-CS conditions, the test trials consisted of the successive presentation of each of the stimulus nouns, but at a 30-sec. rate. The stimulus nouns were read aloud by the E as they appeared on the screen and the Ss recorded as many of the words from the strings as they could recall, including the stimulus nouns, in the appropriate spaces provided on the pages of their response booklets. For the FS-FS condition, the study trial consisted of a four-minute, unpaced interval, during which Ss recorded as many strings as they recalled, in any order, one per page.

At the end of the test trial, and after a 4-sec. inter-trial interval, the second study trial commenced with the successive presentation of the strings. The procedures described were repeated for a total of three complete trials for all Ss.

Subjects. The sample consisted of 96 fifth- and sixth-grade children drawn from a public elementary school in a middle-class neighborhood. Two grades were sampled only in order to obtain a sufficiently large number of Ss, not to test hypotheses regarding grade differences. Six Ss from each grade were randomly assigned to each of the eight conditions and of the six, half were randomly selected to receive one of the lists and the remaining half received the other list. Thus the task was administered to six-person squads each of which was comprised of three fifth- and three sixth-grade children.

Results

In the PA conditions, the amount learned was measured in terms of the numbers of correct responses emitted on the three test trials. Performance in the Verb condition ($\overline{X} = 17.42$) was superior to that in the Conjunction condition ($\overline{X} = 11.58$), $F\ (1,16) = 7.30$, $p < .05$, indicating that the connective difference previously obtained with these materials was viable under the conditions of the present experiment.

Performance on the three string learning tasks was measured in two ways: (a) in terms of the total numbers of entire strings recalled correctly on the three test trials, and (b) in terms of the total numbers of words correctly recalled.

Strings. A string was considered correctly recalled if, and only if, every word in the string was recorded in the position it had occupied in the study-trial materials. The results are shown in Table 8. These data were subjected to analysis of variance in which the sources assessed were: Grades, Lists, Tasks, and Connectives nested within Tasks (See Appendix D-1). Neither Grades nor Lists was a significant source of variance ($F < 1$ in both cases) nor did they have significant interactions with other factors. Differences among tasks, however, were significant, $F\ (2,48) = 12.87$, $p < .01$, and an application of Scheffé's method revealed that performance was better on both the CS-CS and FS-FS tasks than on the PA-CS task. The main effect of connectives within tasks was significant such that more verb than conjunction strings were correctly recalled in both the CS-CS, $F\ (1,48) = 5.31$, $p < .05$, and the FS-FS tasks, $F\ (1,48) = 7.19$, $p < .05$. In the PA-CS task, the mean for

Table 8
Mean Numbers of Strings Recalled as a Function
of Task and Connective

	Task		
	PA-CS	CS-CS	FS-FS
Connective			
Conjunction	2.33	5.75	7.17
Verb	4.42	9.83	11.92

verb strings was larger than that for conjunction strings, as predicted, but the difference was not reliable, F (1,48) = 1.38, p>.05. It will be recalled that in PA-CS, the task instructions were changed between the study and test phases of trial 1. Since this information was available to Ss prior to the remaining trials, only performance on trial 1 in this condition is of particular interest. The number of entire strings correctly reproduced on the initial test trial was negligible: a total of two strings in the conjunction condition and only one string in the verb condition. Thus, in terms of this measure of learning, the data provide no support for the hypothesis that the form class effect may be generalized to the PA-CS method of string learning. A weaker version of the hypothesis was evaluated in terms of the numbers of words correctly recalled and will be considered shortly. With respect to the CS-CS and FS-FS methods of string learning, however, the results are clear: verb strings are easier to learn than conjunction strings. The effect of the form class of context connectives on the amount learned in a PA task had a demonstrably similar effect on the learning of entire strings.

Words. A word was scored as recalled correctly only when it appeared in the proper position in the string in which it was originally presented. A more lenient scoring system, where a word was considered correct even if it was recorded in the wrong position, was also applied to the responses. Since the lenient system yielded results parallel in all respects to those obtained with the strict system, only the latter will be presented. An analysis of variance was performed in which the factors were: Grades (fifth vs. sixth); Lists (A vs. B); Tasks (PA-CS vs. CS-CS vs. FS-FS); Connectives within Tasks (verb vs. conjunction); Trials within Tasks (1 vs. 2 vs. 3); and Constituents within Tasks (first adjective vs. connective vs. second adjective vs. second noun). Trials and Constituents were repeated measures factors (See Appendix D-2).

The results of measuring performance in terms of the numbers of words recalled are presented in Table 9. The main effects of Grades and Lists were not significant, F<1, in both cases. The main effect of Tasks was significant, F (2,48) = 10.96, p<.01, and, as evaluated by the Scheffé method, was located entirely in the inferior performance of the PA-CS groups. The numbers of words recalled from verb strings was significantly greater than from conjunction strings within the FS-FS task, F (1,48) = 4.76, p<.05, but not within PA-CS, F (1,48) = 3.06, p>.05, nor within CS-CS, F (1,48) = 3.61, p>.05. An interpretation of this outcome will be postponed and included in a consideration of the interaction of Connectives with Constituents. The main effect of Trials within Tasks was, of course, significant, F (6,96) = 93.13, p<.01, as was that of Constituents within Tasks, F (9,144) = 12.22, p<.01.

The interaction of principal interest, Connectives x Constituents, was significant within PA-CS, F (3,144) = 11.02, p<.01, and

Table 9
Mean Numbers of Words Recalled as a Function of Task, Connective, and Constituent

Task	Form Class	Constituents Adj. 1	Conn.	Adj. 2	Noun 2	Total
PA-CS	Conj.	8.58	6.15	5.58	8.40	7.17
	Verb	8.34	9.57	7.65	15.51	10.72
CS-CS	Conj.	15.75	12.15	10.59	11.67	12.54
	Verb.	15.75	15.66	14.58	17.67	15.92
FS-FS	Conj.	11.91	9.84	11.16	12.33	11.31
	Verb	14.76	15.15	14.34	16.50	15.19
Total		12.51	11.43	10.64	13.68	

within CS-CS, F (3,144) = 7.34, $p < .01$, but not within FS-FS, F (3,144) = 1.49, $p > .05$. Within these interactions, Scheffé's method of contrasts revealed the following differences: in PA-CS, more connectives and second nouns were recalled from verb strings than from conjunction strings; in CS-CS, more second adjectives, as well as more connectives and second nouns were recalled from verb than from conjunction strings; and, in FS-FS, all four of the string constituents were better recalled in the verb than in the conjunction conditions. Despite the absence of significant main effects associated with the form class of connectives in the PA-CS and CS-CS tasks, more of at least two string constituents were recalled from verb than conjunction strings in all tasks. Thus, the superiority of verb over conjunction connectives is clearly discernible in string learning as well as in the learning of constituent paired nouns.

The results reported for the PA-CS condition were consistent across trials. Specifically, on trial 1, the Scheffé method revealed no connective differences for either of the adjective constituents but the verb strings did produce reliably better mean recall of connectives (2.08 vs. 0.84) and of second nouns (3.51 vs. 1.25) than did conjunction strings.

In an analysis of variance performed on the numbers of second nouns correctly recalled in each of the four tasks, including the simple PA conditions, no differences associated with tasks emerged: $\underline{F}$ (3,64) = 1.51, $\underline{p} > .05$, for the main effect; and, $\underline{F} < 1$, for the interaction with Connectives. In all tasks, however, more second nouns were recalled from the verb than from the conjunction strings, $\underline{F}$ (1,64) = 30.28, $\underline{p} < .01$. It appears that the acquisition of constituent response nouns is as easy when Ss attempt to learn entire strings as when they are instructed to learn only the nouns.

Discussion

With respect to the question that precipitated the present study, the results are clear: a variable relevant to PA learning, namely, the form class of context connectives, is relevant to string learning as well. Within the class of English strings that are syntactically structured, those in which the constituent connectives are verbs can be learned more readily than those in which the constituent connectives are conjunctions. The specific nature of the string learning task, however, appears to determine which of the string constituents are affected by the form class of the connective. When the initial noun from a string is provided as a response cue, form-class differences are detectable only for the constituents of the second noun phrase and for the connectives themselves, whereas in the free learning method, differences are detectable for all string constituents.

Although the present experiment provides no explanation for the form-class difference in string learning, its results are relevant to a proffered explanation of the form-class difference in PA learning. This explanation may be stated in terms of an assumption and three related hypotheses. The assumption is that when noun PAs are presented in the context of grammatical English strings, Ss attempt to learn other portions of the strings as well as the pairs of nouns. If so, the three relevant hypotheses are that: (1) the components of contextual strings in which the two nouns are connected by a verb are easier to learn than those in strings where the two nouns are connected by a conjunction; (2) since the degree of string learning varies with the form class of the context connective, when presented on a test trial, the first noun from a study-trial verb string elicits a greater portion of the original context than the first noun from a study-trial conjunction string; and (3), more correct responses are produced by verb strings because the study-trial context is more completely reinstated in the verb than in the conjunction case. It is suggestive to note that hypotheses (1) and (2) are consistent with the data obtained. The results are, of course, irrelevant to hypothesis (3), but the explanation seems sufficiently promising to warrant an appropriate experimental test of that hypothesis.

Experiment V: The Hypothesis of Context Availability

The present experiment was designed to provide an empirical test of the remaining component (hypothesis 3) of the context availability explanation of the connective form-class effect. In addition, it was designed to investigate an intriguing puzzle, that is, the experiment was also designed to determine the principal loci at which factors related to learning efficiency work their effects. In order to solve the puzzle, the learning process must be divided into components that can be designated as possible loci for the operation of significant learning variables. The two-stage analysis of PA learning into response learning and associative phases has led to notable progress in specifying loci (42). Other subdivisions of PA learning are possible, however, and the one of choice depends largely upon the kind of question being investigated, that is, upon the character of the variable being examined. One alternative analysis also divides PA learning into two phases: a storage phase; and, a retrieval phase. The storage phase may be described in terms of the conditions extant when materials are presented for acquisition, and the retrieval phase in terms of the conditions under which evidence of acquisition is requested from the learner. In this analysis the succession of trials that usually comprise a PA learning task may be viewed as an alternating series of storage and retrieval phases of the learning process.

It is important to note that the present paper is concerned with storage and retrieval processes within original learning (i.e. inter-trial retention). This concern was provoked by the results of the PA experiment reported by Rohwer (33) in which noun pairs presented in the context of a simple declarative sentence (e.g. The running COW chases the bouncing BALL.) were learned more rapidly than the same pairs presented in the context of a matched conjunction phrase (e.g. The running COW and the bouncing BALL) or without any additional context (e.g. COW BALL). Since the observed difference appeared on the first anticipation trial and remained constant across the six trials given to all Ss, it was of interest to inquire whether the sentence contexts affected PA learning at the time they were initially presented, or at the time Ss were first required to anticipate the responses for each stimulus noun. That is to say, the problem was to examine the storage and retrieval components of the process whereby sentence contexts facilitate PA learning.

A major methodological difficulty in a storage-retrieval analysis within original learning turns on the fact that the learner's activity is only assessed at the time of retrieval, but this need not be an insurmountable obstacle so long as it is possible to manipulate the variables of interest at the time of storage independently of their manipulation at the time of retrieval. A study-test method, in which the study trial is identified with storage and the test trial with retrieval, used in conjunction with sufficient numbers of independent groups to exhaust the combinations of storage and retrieval conditions, would permit an informative assessment of the distinct effects produced at each locus.

Independent manipulation of storage and retrieval conditions is only feasible, however, for variables that are not inherent properties of the PA items themselves. Meaningfulness, for example, cannot be varied independently on study and test trials. In contrast, the variable of verbal context is appropriate for the study-test method of investigating loci, since the PA items may be held constant across contextual variation between study and test trials.

The present experiment was designed to permit a decision about two hypotheses concerning the loci at which sentence contexts affect PA learning and the processes whereby the effect occurs. The first of these, a constraint hypothesis, gives principal emphasis to the retrieval phase of initial learning and assumes that verb connectives exert more constraint on subsequent nouns than do conjunction connectives. In the case of PAlearning, verbs are presumed to limit the number of appropriate response nouns more severely than conjunctions, thereby increasing the probability of correct response retrieval and selection. This hypothesis makes no assumptions about differential form-class effects at storage; the availability of the verb connectives at retrieval is held to be sufficient for facilitation.

The critical factor for the second hypothesis, the context hypothesis, is the interaction of the type of storage context (conjunction vs. verb strings) and the extent to which the retrieval context approximates that provided at storage. In general, the greater the similarity between storage and retrieval contexts, the better should be performance, but equal degrees of similarity between the two cannot be assumed for both conjunction and verb strings. In a PA procedure where the overt storage context is an entire string and the overt retrieval context is only the constituent stimulus noun, the similarity between the two varies as a function of the S's capability of covertly recalling the remainder of the storage context. Since verb strings of the kind used by Rohwer (33) are better recalled after a single presentation than comparable conjunction strings (Experiment IV), the effective retrieval and storage contexts are more similar in the case of verb than in the case of conjunction strings. It follows that PA performance should be higher in the former than in the latter. If this hypothesis is true, then the superiority of verb contexts should be eliminated when the storage contexts in both verb and conjunction conditions are made equally available at the time of retrieval. Note that this prediction contradicts the one implied by the constraint hypothesis.

Method

Materials and design. In a 3 x 2 x 2 factorial design with a single control, all Ss were asked to learn the same list of fourteen pairs of high-frequency nouns by the study-test method. The first of the principal independent variables concerned the locus of the appearance of the PA contexts used and consisted of three levels.

For one condition, storage (ST), the paired nouns were presented in the context of syntactically structured English strings during the study trial, but not during the test trial, when only the stimulus noun was presented. For a second condition, retrieval (RE), the pairs of nouns were presented alone during the study trial, but during the test trial, each stimulus noun was presented in the context of a syntactical English string, except for the response noun which the S̲ was asked to supply. In the remaining condition, ST + RE, string presentation was used on both the study trial and the test trial.

The second of the principal factors concerned the form class of the word in each string used to connect the two nouns to be learned. In half the conditions, this word was a conjunction and in the other half, it was a verb.

The third factor in the design was included only to provide information regarding the materials of choice for subsequence experiments. That is to say, half of the strings included a modifier for each noun presented (such that each string was of the form: article, adjective, noun, connective, article, adjective, noun) and the other half did not (such that each string was of the form: article, noun, connective, article, noun).

Finally, the outside control consisted of the presentation of the pairs of nouns during the study trial and of the stimulus nouns during the test trial. In effect, the control group was a condition in which strings were neither presented during storage nor during retrieval.

The fourteen PAs consisted of pairs of high-frequency nouns. For each pair a simple declarative sentence was constructed in which the two nouns were connected by a high-frequency verb (e.g. The COW chases the BALL). A total of 14 different verbs was selected, one for each noun pair. The same strings were used for the conjunction condition except that one of two coordinate conjunctions (and, or) was substituted for each of the verbs (e.g. The COW and the BALL). Thus, in terms of the contextual strings, intralist similarity was greater among the conjunction phrases than among the sentences. Since this variety of intralist similarity has been shown to be irrelevant to the present task (Experiment I), the distribution of different words in the two form classes was permitted to reflect the distribution in the language. In the case of conditions in which modifiers were used, each string was expanded for both conjunction and verb groups to include two adjectives (e.g. The running COW chases the bouncing BALL.). Whenever the nouns were presented in the context of strings, they were capitalized and underlined. In those conditions calling for the presentation of strings during the test trial, the corresponding study-trial strings were used, except that the response noun was deleted (e.g. The COW chases the ____.). All materials were photographed and presented by means of

2 x 2 slide transparencies.

Subjects. The sample consisted of 104 fifth- and 104 sixth-grade children drawn from an upper-middle class public elementary school. Two different grades rather than one were sampled in order to obtain a sufficiently large number of *Ss* rather than because of any particular interest in grade differences. Eight children from each grade were randomly assigned to each of the thirteen conditions of the experiment.

Procedure. Each *S* was tested individually. At the outset, the task was described and *Ss* were asked to memorize the 14 pairs of words in such a way that they could supply the second noun of a pair when presented with the appropriate stimulus. An example was used to illustrate both the study and test trials for each of the various conditions so that all *Ss* were apprised of the nature of the study and test trials they would receive. The study trial then commenced with the successive presentation of the 14 slides at a 5-sec. rate, during which *E* read all verbal materials aloud, followed after 10 secs. by the test trial in which the specified items were again presented at a 5-sec. rate and again read aloud by *E*, but in an order different from that used during the study trial. Only one complete trial was given to all *Ss*, since previous research (33) has demonstrated the redundancy of information derived from additional trials.

Results

Learning was measured by the number of correct responses given during the test trial. The design was treated as nested within grades and the analysis of variance was performed accordingly (See Appendix E-1). Since variation between grades was not significant, F (1,206) = 2.06, $p > .05$, and since all other effects were consistent across grades, grade distinctions are not made in the results presented. No significant differences in learning were associated with the presence or absence of modifiers in the strings, $F < 1$, nor were any of the interactions of modifiers and other factors significant. The results for the seven principal conditions are presented in Table 10.

The main effect for the locus factor was significant, F (4,182) = 18.86, $p < .01$. Scheffé's method was applied to the differences within the locus factor and revealed that ST strings produced better performance than RE strings, and that ST + RE strings produced better learning than ST strings.

The main effect for form class was also significant, F (2,182) = 22.83, $p < .01$, such that verb connectives produced better performance than conjunctions. The form class difference, however, held only for the ST and ST + RE conditions and not for the RE condition, that is, the interaction of the form class and locus factors was

Table 10

Mean Numbers of Correct Responses as a Function of Context Locus and Form Class

Form Class	Context Locus ST-RE	ST	RE	Total	Control
Conjunction	4.94	3.75	3.32	4.00	4.44
Verb	9.56	6.66	3.28	6.50	
Total	7.25	5.20	3.30		

significant, F (4,182) = 7.05, $p < .01$. Facilitation was indexed by the difference between the numbers of correct responses produced by the context conditions and by the control group. Dunnett's test revealed no facilitation in the RE condition. In contrast, there was facilitation in the ST-verb condition, even though it was significantly smaller in magnitude than that observed in the ST + RE-verb condition. No facilitation was observed in any of the conjunction conditions. The Scheffé method indicated that performance produced by conjunction strings did not vary significantly with storage and retrieval conditions, whereas the learning produced by verb strings did. Verb strings at ST + RE produced better performance than verb strings at ST only, and verb strings at ST produced better performance than verb strings presented at RE only.

Discussion

The results indicate that the presentation of verb strings at the time of storage is a sufficient condition for the facilitation of PA learning but that the availability of the strings at the time of retrieval is not. This outcome directly contradicts the constraint hypothesis, thereby corroborating the results of the independent test of that hypothesis reported in Experiment II. The data also contradict the context hypothesis that differences in the availability of conjunction and verb strings were responsible for the facilitation reported by Rohwer (33). In ST + RE, the availability of the storage contexts at retrieval was equated for both kinds of strings and yet the facilitation produced by verb connectives was greater than when the strings were presented at ST only.

It might be argued that the superiority of the ST + RE verb condition is due to the reinstatement of a greater portion of the total initial stimulus. This line of reasoning, however, would lead to a similar prediction for the conjunction strings. The data do not afford support for this prediction since the ST + RE conjunction condition was not significantly superior to the ST conjunction condition. The ST conjunction strings, as well as the ST verb strings, the RE verb strings, and the RE conjunction strings, should also have produced performance inferior to that of the control group since the study and test trials were similar in the latter condition. The data, however, do not bear out these predictions either.

A third interpretation of the inferior performance in the RE-verb condition concerns differences in the length of the response interval for the ST and the RE groups. Since Ss in the former were shown only stimulus nouns on the test trial, more time was available for responding than in the RE conditions where the stimulus nouns were presented in the context of strings read aloud by E. Although it is consistent with the results of the verb conditions, this interpretation does not fit the data for the conjunction conditions where the predicted difference failed to occur.

The results of the present experiment justify the following inferences: in the present paradigm, the presence of sentence context at the time of initial storage is a necessary condition for facilitation; and, the availability of verb-string contexts at the time of retrieval alone is not sufficient to produce increased learning efficiency. The question whether or not the availability of sentence context at the time of retrieval is a necessary condition for facilitation, however, remains unanswered. Nature is recalcitrant on this point; the ideal design requires that PAs be presented in sentences during the study trial and that the sentences but not the PAs be erased by the time the test trial occurs. A procedure for accomplishing this is much to be sought after.

Experiment VI: The Hypothesis of Unit Familiarity

Three explanations for the connective form-class effect have now been proposed and tested: the hypothesis that verbs impose more semantic constraint on the number of appropriate response nouns; the hypothesis that verbs reduce the amount of intralist similarity in a list of noun pairs; and the hypothesis that because verb strings themselves are easier to learn than conjunction strings their availability at recall increases the probability of response retrieval. Experimental tests demonstrated that these explanations were not sufficient to account for the phenomenon.

Another possible explanation for the observed difference between conjunction and verb strings concerns a variable which, in previous research, has been confounded with the variable of connective form class, namely, the type of grammatical unit used as a contextual string. Two nouns connected by a verb form a complete sentence (e.g. "The ROCK hit the BOTTLE.") while two nouns connected by a conjunction do not (e.g. "The ROCK and the BOTTLE"). On the assumption that such sentences are more familiar to children than conjunction phrases, it might be argued that the differences previously obtained were not due to the form class of the word connecting the nouns but rather to the contrast between sentences and phrases.

The present experiment was designed to provide a direct test of this hypothesis by manipulating connective form class while holding constant the type of grammatical unit in which the two connectives occurred. This was done by constructing two kinds of strings, both of which were sentences and both of which contained conjunctions as well as verbs. One kind of sentence was characterized by a compound subject (two nouns connected by a conjunction) followed by a verb that took a pronoun as its object while the other kind was characterized by a simple subject (a noun) followed by a verb that took a compound object (a noun and a pronoun connected by a conjunction). The two kinds of sentences were matched for the number and identity of their word constituents and were distinguished only by the positions of their conjunctions and verbs; in the first, the two nouns were connected by a conjunction whereas in the second, the two nouns were connected by a verb. The effect of connective form class in these kinds of strings was compared with its effect in strings of the kind used previously where verb strings were sentences and conjunction strings were not. If "sentencehood" accounts for the facilitation of noun pair learning, a form-class difference would be expected only in the latter case. Alternatively, if connective type _per se_ is the critical condition for facilitation, a form-class effect would be expected in both cases.

Method

Materials and design. The design was a 2 x 2 factorial in which the principal independent variables were: String Type (Type I vs. Type II); and, Connective Form Class (Conjunction vs. Verb). Twelve pairs of high frequency nouns used in previous research (34) were the learning materials in the present study. The contextual study-trial strings for the Type I verb condition were simple declarative sentences of the form article-noun-verb-article-noun, e.g."The ROCK hit the BOTTLE." A parallel set of strings for the Type I conjunction condition was derived from these by substituting the conjunctions _and_ and _or_ for the verbs, e.g. "The ROCK and the BOTTLE". Complete sentences were constructed from these conjunction strings for the Type II conjunction condition by adding a verb and an object pronoun, e.g. "The ROCK and the BOTTLE hit him." Materials for the Type II verb condition were produced by simply interchanging the two connectives in the corresponding conjunction strings, e.g. "The ROCK hit the BOTTLE and him." Note that the words and the number of words in the two strings were identical.

Subjects. Seventy-two sixth-grade children from a public elementary school in a middle-class residential area served as _Ss_. The _Ss_ were randomly assigned to the four different experimental conditions.

Procedure. The task was administered individually by a study-test method. Subjects were instructed to memorize the pairs of words such that when one member of a pair was shown on the screen the otherword that had appeared with it could be recalled. They were also told that a sentence or phrase would be read for each pair of words. One example was given and a string appropriate to the condition was read.

During the study trial the noun pairs were presented successively by means of a slide projector. Each slide remained on the screen for five seconds, during which time the E read the appropriate string aloud. Note that only the noun pairs, and not the contextual strings, were presented visually. The inter-trial interval was 5 seconds. During the test trial the stimulus nouns were also presented successively, but in a different random order, at a 5-sec. rate and E read them aloud. The Ss responded orally and E recorded the responses. All Ss received two complete trials.

Results

The dependent measure was the number of response nouns correctly recalled on the two test trials. The results are presented in Table 11 as a function of connective form class and string type.

Table 11
Mean Numbers of Responses Correctly Recalled as a Function of Connective Form Class and String Type

Form Class of Connective	String Type		
	Type I	Type II	Total
Conjunction	7.28	4.94	6.11
Verb	8.31	6.97	7.64
Total	7.79	5.96	6.88

An analysis of variance performed on these data (See Appendix F-1) showed a significant main effect of String Type, F (1,68) = 15.68, $p < .01$; Type I strings produced more efficient learning of response nouns than Type II strings. This difference may be due to the use of the same presentation rate for all conditions. That is, whether or not the Ss heard the shorter (Type I) or the longer (Type II) strings the nouns remained on the screen for five seconds. Thus, the lower performance observed in Type II string conditions may be a reflection of the smaller amount of available study time per word than was the case in the Type I string conditions. The main effect for Connective Form Class was also significant, F (1,68) = 10.89, $p < .01$, such that verb connectives produced better recall of response nouns than conjunction connectives. As an inspection of Table 11 indicates, the hypothesis that the difference between the conjunction and verb strings would be reduced in the Type II conditions was not confirmed. Indeed, in direct contradiction of the prediction, the form class difference appears larger in the Type II than in the Type I condition even though the interaction of String Type and Connective Form Class was not significant, F (1,68) = 1.17, $p > .05$. Thus, verb connectives produced more efficient learning of noun pairs even when the contrasting conjunction connectives were also lodged in complete sentences. Briefly then, the shorter strings produced better learning than the longer strings and, in both types of strings, those in which the nouns were connected by a verb produced superior recall to those in which the nouns were connected by conjunctions.

Discussion

The results of the present study fail to support the hypothesis that the difference in performance produced by conjunction and verb connectives is a function of the difference between phrases and sentences. In the Type II strings where both the conjunction and the verb connectives were lodged in complete sentences, strings with compound subjects produced recall inferior to that of strings with compound objects. That is to say, noun pairs connected by verbs were learned more readily than noun pairs connected by conjunctions even though "sentencehood" was common to both. It appears that the actual linking of the nouns by the verb is crucial in facilitating paired-associate learning.

Unfortunately, however, the present results are not sufficient to lay to rest conclusively all explanations of the form-class effect in terms of familiarity. It remains possible to conceive that the Type II verb strings are more familiar linguistic units to children than the Type II conjunction strings. Nevertheless it is clear that the specific elements of the familiarity hypothesis must now be changed. The contention can no longer be that the form-class effect emerges because sentences are more familiar units than phrases; instead it must be that sentences having compound direct objects are more familiar than sentences having compound subjects. The latter hypothesis might be evaluated by ascertaining the relative frequency of the two kinds of sentences in the reading materials furnished children by the schools and in the spontaneously uttered speech of children.

Another possible explanation was negated because of the nature of the Type II strings. Previously, it might have been argued that a list of strings containing only two different conjunctions (and, or) is higher in intralist similarity which in turn leads to a greater degree of interference and correlatively slower learning than a list of strings containing as many different verbs as noun pairs. This was tested previously (Experiment I) by using only two verbs in a list of eight strings; it was found that the verb strings still produced better recall. Both Type II conjunction and Type II verb strings in this study contained identical words, and, therefore, identical amounts of formal intralist similarity but were still associated with different amounts of learning.

A second interpretation consistent with the present data is based on the assumption that the linguistic structure of a sentence determines the units in terms of which sentences are encoded.[2] But this interpretation is complicated by the fact that two kinds of sentence structure may be distinguished: first, surface structure, that is, the actual syntactical form of the sentence; and, second, deep structure, a set of syntactically simple underlying strings (or an underlying string) that express the meaning of the sentence (29). The encoding units implied by these two kinds of sentence analyses differ depending on whether the focus is the syntactic or the semantic component of linguistic structure and consequently, so do the predictions which may be made about learning. The inference from an analysis of surface structure is that learners encode in sub-sentence units and that these units are the actual phrases (sequences of words) of the sentence to be learned. In a simple declarative sentence, the noun phrase and the verb phrase would be the two major units. In contrast, the inference from an analysis of deep structure is that the input to the memory system is in the form of underlying strings.

If it is assumed that the functional storage units in sentence learning are constituent phrases, then the prediction follows that transitional errors should be greater between phrases of a sentence, that is, at phrase boundaries, than within phrases. Two words occurring in the same phrase should be learned faster than two words occurring in different phrases. On the other hand, if it is assumed that underlying strings are the functional storage units then the prediction would be that two words occurring in the same underlying string, although not in the same (surface) phrase, would be learned faster than two words occurring in two different underlying strings.

Predictions about sentence learning derived from phrase- or surface-structure analysis have been confirmed in a study by Johnson (17) using a paired-associate task. With respect to the results of the present experiment, however, a phrase-structure analysis leads to erroneous predictions. A surface-structure analysis of the two kinds of sentences used in the Type II string conditions yields the following major phrase boundaries:

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[2] The author wishes to thank Dr. Paul Ammon for his guiding suggestions in the development of this interpretation.

Conjunction: The ROCK and the BOTTLE / hit him.
Verb: The ROCK / hit the BOTTLE and him.

Accordingly, a larger number of correct responses should have occurred in the Type II conjunction condition than in the corresponding verb condition since both members of the noun pair in the former string occur within the same phrase whereas in the latter string, the two nouns are separated by a major phrase boundary. The discrepancy between this result and that reported by Johnson (17) may be a function of differences in the ages of the Ss in the two samples and in the requirements of the two tasks. Johnson's adult Ss were asked to learn entire sentences as responses in a paired-associate task while the sixth-grade Ss in the present study were asked to learn one constituent of each sentence as a response to another.

An analysis of the underlying structure of the Type II conjunction and verb strings yields the following components:

Conjunction: The ROCK hit him. The BOTTLE hit him.
Verb: The ROCK hit the BOTTLE. The ROCK hit him.

The prediction derived from this analysis is that performance should have been better in the verb than in the conjunction condition since both nouns are found in a single underlying string in the former case but not in the latter where they do not co-occur in either of the underlying strings. If the first noun presented as a stimulus is presumed to function as an entry into storage, then in the case of a verb string, it could retrieve the second noun as a response directly from one of the units as stored. In the case of a conjunction string, however, retrieval of the second noun from a unit in which it co-occurs with the first noun would require the reconstruction of the original sentence. The present results are, of course, consistent with this prediction suggesting that for sixth-grade children the initial storage units in sentence learning are underlying strings. The present status of this interpretation is obviously tentative but it does imply predictions about the relative ease of noun pair learning for a variety of kinds of sentence context. Thus the question of whether or not the hypothesis has validity is clearly open to empirical evaluation.

Experiment VII: Conditions of Sentence Facilitation

Thus far, a satisfactory account of the form-class effect has neither been given nor validated and one of the obstacles may be that the phenomenon has been described in insufficient detail to permit explanation. Thus, the purpose of the present experiment was to specify more precisely the conditions under which the presentation of noun pairs in the context of sentences facilitates acquisition.

Typically, the phenomenon has been detected with sentences in which one of the nouns occupies the subject position in the contextual string and the other occupies the position of direct object. In such sentences, the verb has been referred to as a connective which joins the two nouns to be learned. Rohwer (33) found that conjunctions, as connectives, are less effective than verbs in promoting efficient learning, thereby posing the question: What are the properties of verbs that are responsible for the observed facilitation? Specifically, it may be asked if facilitation has been found because verbs often imply overt action involving the objects named by the subject and object nouns in a sentence. One of the ways verbs and conjunctions differ is that the former frequently refer to episodes of overt action while the latter do not. If implied overt activity is the property of verbs responsible for facilitation, then verbs that do not refer to overt activity should not produce facilitation of noun-pair learning.

A second factor of possible relevance is suggested by the demonstrated relationship between semantic structure and the learning of entire strings of words. Marks and Miller (19) reported that normal sentences are better learned than anomalous sentences in which English word order is preserved but in which string meaning or semantic structure is violated by the particular combination of words concatenated. If the learning of constituent noun pairs is governed by the same law as the learning of entire strings, then less facilitation of PA learning should be produced by anomalous sentence contexts than by normal sentence contexts.

Finally, a third issue concerns the nature of the functional stimulus when a noun pair has been presented in a sentence context. In a previous study (Experiment V) it was shown that as a stimulus for the object noun, the subject noun from such a context is not as effective as the entire portion of the sentence preceding the object noun. It might be inferred from this result that the sentence, as a configuration, is the functional stimulus (cf. 41). It is also possible, however, that the verb from such a context serves by itself as the functional stimulus. If so, the presentation of the verb from a contextual string as the test stimulus should produce performance equivalent to that produced by the presentation of the subject noun with the verb.

Method

Materials and design. A 2 x 2 x 3 factorial design with two independent control groups was used to assess the relevance of three factors to the learning of paired nouns. The first factor, Activity, contrasted verbs implying overt action (Action) with verbs implying little or no overt action (Still). The second factor, Meaningfulness, compared the effects of normal sentence contexts with those of anomalous sentence contexts. The third factor was Test Stimuli, in which the nature of the test trial stimulus was varied (Subject Noun vs. Verb vs. Subject Noun and Verb).

Four lists of 12 three-word sentences were constructed, one for each of the conditions produced by the factorial combination of the Activity and Meaningfulness factors. The sentences for the Normal-Action (NA) condition were produced first by simply inserting a semantically appropriate verb implying overt action between the two high-frequency nouns in each of the twelve pairs (e.g. ROSES drink RAIN.) The sentences for the Normal-Still (NS) condition were then derived by substituting semantically appropriate verbs which did not imply overt activity for those used in NA materials (e.g. ROSES like RAIN.). Sentences for the Anomalous-Action (AA) condition were formed by substituting semantically inappropriate nouns in the direct object positions of the NA sentences (e.g. ROSES drink HATS.). Finally, Anomalous-Still (AS) sentences were constructed from those used in NS by replacing the direct object nouns with those used in AA (e.g. ROSES like HATS.).

It is important to note that the list of noun pairs used in the Anomalous conditions was different than that used in the Normal conditions, even though the stimulus nouns were identical in both cases. This method of manipulating the meaningfulness of the two sets of strings was chosen over the alternative of varying the verbs used in the two conditions in order that the definition of the distinction between Still and Action verbs would be identical for both the Normal and Anomalous strings. In contrast to the difficulties involved in an attempt to control for verb differences in the latter kind of design, it was a straightforward matter to control for possible differences in list difficulty in the present design. One group of Ss was asked to learn the N list of pairs and another was asked to learn the A list in the absence of any additional context. The study-trial materials for the two control conditions, N and A, consisted of the noun pairs used in the NA and NS sentences and the Noun pairs used in the AA and AS sentences, respectively.

Three different kinds of test-trial materials were used within each of the four Activity x Meaningfulness conditions. In the first (S) only the subject nouns were presented as stimuli to which the direct-object nouns were to be given as responses. The second set of materials (V) consisted only of the verbs from each of the sentences as stimuli. And the third set of test-trial materials (S & V) presented both the subject nouns and the verbs from the study-trial sentences as stimuli. The test-trial stimuli in both control conditions were simply the first nouns from each of the pairs.

All materials were typed on white, 4 x 6-in. cards in 5/32-in.

type, one pair per card. Whenever they appeared, all nouns were capitalized and underlined to duplicate the format used in previous research. All cards for each condition were placed in small looseleaf binders for presentation to *Ss*.

Procedure. The task was administered to *Ss* individually by two *Es*, according to a study-test method for one complete trial. Additional trials were deemed unnecessary in view of the fact that the phenomenon of interest has been shown to appear on the first learning trial and to remain constant across subsequent trials (33). One *E* presented instructions and the study- and test-trial materials, while the other recorded *Ss*' responses.

In the instructions, *Ss* were told that they would be shown a series of sentences (Controls: a series of word pairs) and that their task was to learn these in a way such that when shown part of each sentence (Controls: the first word from each pair) they could tell *E* what the last word in the given sentence (Controls: second word in each pair) had been. The study-trial items were presented successively at a 3-sec. rate and were read aloud by *E* as they appeared. The test trial followed immediately in which the stimulus terms were presented at a 3-sec. rate and read aloud by *E* but in an order different from that of the study trial.

Subjects. Of a total of 112 fifth-grade children drawn from two public elementary schools in a middle-class neighborhood, eight were randomly assigned to each of the 12 experimental and the 2 control conditions.

Results

Learning was measured in terms of the number of correct responses made on the test trial. The results are presented in Table 12. An analysis of variance was performed in which the variance associated with conditions was partitioned in a manner similar to that suggested by Winer (45, p. 263) such that all observations from the control conditions, as well as those from the experimental conditions were included (See Appendix G-1). The Activity factor produced no significant differences in performance, $F < 1$. Either (a) sentences do not evoke mediate pictorial responses of the activities implied or, (b) the two categories of verbs, A and S, were not sufficiently different with respect to the amount of overt activity implied to produce effective differences in the nature of the pictorial responses evoked.

Since different lists of paired nouns were used in the Normal and Anomalous conditions, it is critical to determine whether or not the two lists differed in difficulty before evaluating the effect of the Meaningfulness factor. There was no significant difference between the two control conditions, $F < 1$. As the two lists do not appear to differ in difficulty, the significant

Table 12
Mean Numbers of Correct Responses as a Function of
Activity, Meaningfulness and Test Stimuli

	Normal		Anomalous		
Test Stimuli	Action	Still	Action	Still	Total
Nouns	6.00	7.37	5.00	4.62	5.75
Verbs	3.50	3.87	1.12	2.00	2.62
Nouns and Verbs	9.00	7.87	4.25	4.75	6.47
Total	6.27		3.64		
Controls	4.12		3.62		

superiority of the Normal sentences over the Anomalous ones, F (1,98) = 29.52, $p < .01$, can be attributed to the difference in semantic structure. Dunnett's test indicated that, relative to the appropriate control conditions, Normal sentences produced facilitation of PA learning, t (2,98) = 2.38, $p < .01$, but Anomalous sentences did not, t (2,98) = .02, $p > .05$. Clearly the effect of semantic structure on the learning of entire sentences holds for the learning of constituent noun pairs as well.

The effect of the third factor, Test stimuli, was significant, F (2,98) = 24.13, $p < .01$, and accounted for a substantial percentage of the total variance, 26 percent. Contrary to the prediction that verbs are the major functional stimuli, the Scheffé method of comparisons revealed that V test stimuli produced fewer correct responses than either N or N & V test stimuli, $p < .01$, whereas the latter did not differ, $p > .05$. As assessed by Dunnett's test, facilitation was produced by N stimuli, t (4,98) = 1.87, $p < .05$, and by N and V stimuli, t (4,98) = 2.69, $p < .01$, but not by V stimuli, that is, the combined control conditions did not differ significantly from the V conditions, t (4,98) = 1.26, $p > .05$.

None of the tests for interaction was significant. Only one, Meaningfulness x Test stimuli, F (2,98) = 1.70, $p > .05$, produced an F-ratio in excess of unity.

Discussion

In terms of the intent of the present experiment, namely, to specify some of the conditions under which verb connectives do and do not facilitate the learning of noun pairs, the following conclusions are clearly indicated. Verbs that imply relatively little overt activity involving the two objects named by the noun pairs produce as much facilitation as verbs implying considerable overt activity. Semantically anomalous sentence contexts, however, do not facilitate the learning of constituent noun pairs whereas normal sentence contexts do.

Perhaps the most intriguing aspect of the results concerns the failure of V test stimuli to elicit as many correct responses as elicited by the N test stimuli. It might be argued that the presentation format, in which nouns but not verbs were capitalized and underlined, is responsible for performance differences associated with the three types of test stimuli. The format does indeed de-emphasize the verbs, but this is not a sufficient explanation since, as study-trial connectives, verbs nevertheless facilitate performance. If the process whereby verb connectives facilitate the learning of noun pairs consists of the selection of the verbs as functional stimuli, then the verb in each string, when presented overtly, should reliably elicit the appropriate response noun. The present results demonstrate that this is not the case, at least not for the majority of the pairs in a list. It may be, however, that the verbs serve as functional stimuli for some but not all of the pairs; the verb test stimuli did elicit correct responses, even though the number of these was quite small.

Three additional interpretations should also be mentioned. The first is that the subject noun and the verb serve as a single configurational stimulus for the object noun. The second is that independent associations are formed between the subject and object nouns and between the verb and object noun. The third is that an association is formed between the subject noun and the verb and between the verb and the object noun such that on test trials the verb mediates between the subject and object nouns. Although no one of these three interpretations is entirely discounted by the present results, each implies the prediction that the N + V condition should produce the best performance and this prediction was not confirmed.

The interesting discrepancy is that the presentation of verb connectives during the study trial produces a major difference in performance whereas its presentation during the test trial does not. One implication of this, namely that the effect of verb connectives on the learning of noun pairs occurs principally at input, is consistent with results of an experiment reported previously (Experiment V) in which the presence of verb connectives at the time of output alone was shown to be irrelevant to PA performance. Given that the locus of the effect is at input, the puzzle is to describe the process occurring at that time which facilitates learning.

Experiment VIII: Sentence Elaboration--Pictorial vs. Printed Materials

Surely, one of the important tasks of pedagogy is to create conditions that produce efficient learning. Two possible ways of accomplishing this task, at least for the kinds of learning that conform to the paired-associate paradigm, are close at hand. The first derives from evidence already reported in the series of studies on the effects of sentence contexts on the learning of noun pairs. A second method that appears to have potential for promoting learning efficiency is that of presenting materials pictorially rather than in print. In connection with the question whether or not foreign-language words are learned more easily when associated with their environmental referents or when associated with native-language word equivalents, Wimer and Lambert (44) found that nonsense syllables were learned faster as responses to objects than as responses to the printed names of the objects. Since frequently it is difficult to use many kinds of actual objects as learning materials, whether it be in the classroom or in the laboratory, it is important to know whether the demonstrated superiority of objects over words extends to pictures of objects as well. Furthermore, it remains to be shown whether or not differences in materials produce differences in learning efficiency when both the stimulus and the response members of paired associates are familiar.

The purpose of the present experiment was threefold: first, to replicate the graded facilitation associated with connective form class found by Rohwer (33) on both printed and pictorial materials; second, to determine whether the increased learning efficiency produced by sentence contexts can be further augmented by the use of pictorial materials; and, third, it was of interest to determine whether or not the predicted superiority of pictorial materials would decrease with age over an interval during which verbal facility presumably increases.

Method

Materials and design. The principal factors in a 2 x 2 x 4 factorial design were: Grades (third vs. sixth); Materials (printed vs. pictorial); and, Verbalization (conjunction vs. preposition vs. verb vs. control). Both the printed materials and the pictorial materials were presented by projection on a beaded screen. The pictorial study-trial materials consisted of 16 mm. black and white movie film bearing the images of 24 pairs of objects that were photographed against a neutral grey background and foreground for a total of four seconds each. The test trial materials consisted of similar movie photographs of one object from each of the 24 pairs. The printed study-trial materials were pairs of words (the names of the corresponding objects in the picture materials) and the test-trial materials were the initial words from each pair photographed and mounted as 2 x 2-in slide transparencies. A complete list of the 24 pairs of objects/words is presented in Table 13.

Table 13
Study-Trial Materials

Strings and Objects/Words	Connectives
1. The FORK _____ the CAKE.	or, on, cuts
2. The TOWEL _____ the PLATE.	and, across, wipes
3. The CAT _____ the LOG.	or, over, jumps
4. The MAN _____ the POLE.	or, beside, bends
5. The BAT _____ the CUP.	and, in, strikes
6. The SHOE _____ the CHAIR.	and, beneath, taps
7. The BOAT _____ the BALL.	and, against, rolls
8. The HAND _____ the HAT.	or, inside, throws
9. The ROCK _____ the BOTTLE.	or, behind, breaks
10. The CAR _____ the WAGON.	and, under, upsets
11. The ROPE _____ the EYE.	and, around, rubs
12. The NEEDLE _____ the BALLOON.	or, outside, pops
13. The DOG _____ the GATE.	and, on, closes
14. The SPOON _____ the EGG.	and, under, rolls
15. The FIRE _____ the BED.	and, behind, burns
16. The AX _____ the WOOD.	and, upon, hits
17. The KNIFE _____ the FLOWER.	or, below, cuts
18. The BLANKET _____ the TREE.	or, around, covers
19. The MILK _____ the BOWL.	and, inside, fills
20. The TEETH _____ the APPLE.	or, near, bite
21. The HAMMER _____ the BELL.	or, over, pulls
22. The PENCIL _____ the PAPER.	or, across, tears
23. The DOLL _____ the BOOK.	and, against, opens
24. The FOOT _____ the HOUSE.	or, above, kicks

All verbalizations were uttered by E as he read from a prepared script. Five-word sentences of the form article-noun-verb-article-noun were constructed for each of the 24 pairs of objects/words and constituted the materials for the verb conditions. Comparable strings for the preposition and conjunction conditions were derived from the verb strings by substituting prepositions and conjunctions, respectively, for the verbs. Verbalization for the control conditions simply consisted of the E uttering the names of the two objects in each pair or reading the two words in each pair to the S. A complete list of the scripts used by E is presented in Table 13.

Subjects. The sample consisted of 96 third- and 96 sixth-grade children drawn from a school district in a middle-class area. Two grade-level populations were sampled in order to provide information as to the relative effectiveness of picture and word materials for children of presumably lesser and greater verbal proficiency. A population younger than that in the third grade was avoided in view of the possibility that reading of the word materials might be problematical. The prediction was that the expected superiority of the pictorial over the printed materials would be greater for the third- than for the sixth-grade pupils. Within each grade, 12 *S*s were assigned randomly to each of the 8 experimental conditions.

Procedure. The task was administered individually by a study-test method for a total of two complete trials. Since two male adults served as *E*s, the assignment of *S*s was randomized and balanced with respect to experimenters as well as with respect to experimental conditions. When an *S* entered the experimental room, he was seated in front of a projector, at a distance of approximately ten feet from the screen. The slide and the movie projectors produced comparable levels of noise in the experimental room and the same projection screen was used with both.

The instructions informed the *S* that he would be shown 24 pairs of objects/words and that he was to learn them in such a way that he could produce the name of the second member of each pair when shown the first. One example was given orally after which the first study trial commenced. During the study trial, the pairs were presented successively at a 4-sec. rate, and, as each pair appeared on the screen, *E* uttered the appropriate verbalization. After a 4-sec. inter-trial interval, the test stimuli were presented successively, again at a 4-sec. rate but in an order different from that of the study trial, and, as each stimulus appeared, *E* read or named it aloud. The same procedure was followed on the second trial, except that the items were presented in different orders. Responses were made orally and were recorded by *E*.

Results

The amount learned was measured in terms of the total numbers of correct responses given on the two test trials. Mean numbers of correct responses are presented in Table 14 as a function of Grades, Materials and Verbalization. In the four-way analysis of variance performed on these data (See Appendix H-1), the main effect for Grades was not significant, F (1,160) = 1.41, $p > .05$, nor was the expected interaction of Grades with Materials, $F < 1$. Clearly, however, learning was more efficient with pictorial than with printed materials, F (1,160) = 122.24, $p < .01$, in both grades, so much so that more than 32 percent of the total variance was associated with this factor.

The question whether or not the connective form class effect reported by Rohwer (33) is replicable receives an affirmative answer in the present results. The main effect of Verbalization was significant, F (3,160) = 13.63, $p < .01$, and, of the three string conditions, only the Verb was superior to the control, confirming the results of previous experiments in which the presentation of paired nouns in sentence contexts increased learning efficiency.

Table 14
Mean Numbers of Correct Responses as a Function of Grade, Material, and Verbalization

		Verbalization				
Material	Grade	Conj.	Prep.	Verb	Control	Total
Printed	3	14.24	19.24	24.08	15.42	18.25
	6	13.34	23.16	22.50	19.92	19.73
Printed Total		13.80	21.20	23.30	17.66	18.99
Pictorial	3	23.76	28.58	33.16	29.08	28.64
	6	30.08	25.66	33.76	27.76	29.31
Pictorial Total		26.92	27.12	33.46	28.42	28.98
Total Group		20.36	24.16	28.38	23.04	23.98

As for differences associated with connective form class, more was learned with verb connectives than with prepositions which, in turn, were superior to conjunctions. The form of the relationship between connective form class and learning efficiency, however, appears to depend upon whether the materials are words or pictures and upon the grade level of the Ss. The interaction of Materials and Verbalization was significant, F (3,160) = 2.76, $p < .05$, such that for printed noun pairs, the difference between the verb and preposition connectives was not significant but each was superior to conjunctions. This outcome is consistent with the results obtained by Rohwer (33) with printed materials. In contrast, verb connectives in the pictorial conditions were superior to both prepositions and conjunctions which did not differ significantly from one another.

An examination of the three-way interaction, Grades x Materials x Verbalization, F (3,160) = 3.45, $p < .05$, revealed that the interaction Materials x Verbalization already described was located entirely in the sixth-grade samples, F (3,160) = 6.21, $p < .01$, and not in the third-grade samples, $F < 1$. For the latter Ss the effects of connective form class were virtually parallel in the printed and pictorial conditions; in both cases, the difference between verbs and prepositions was as large as the difference between prepositions and conjunctions.

The main effect of Experimenters was not significant, $F < 1$, nor were any of the interactions involving this factor, with the exception of Experimenters x Materials x Verbalization, F (3,160) = 2.91, $p < .05$. An appraisal of this interaction indicated that the direction of the differences obtained was consistent across Es but the magnitudes varied, i.e., pictures were superior to words and verb connectives were associated with the greatest amount of learning for both Es.

In sum, the presentation of paired associates in pictorial form and in the context of sentences produces more efficient learning than any other combination of conditions examined, and, the form class of context connectives is consistently associated with the amount learned, although the detailed form of that relationship appears to depend on the grade level of the Ss and on the character of the learning materials.

Discussion

The present demonstration of the superiority of pictorial over printed word materials for the promotion of efficient paired-associate learning raises two kinds of additional questions. The first concerns the scope, the possibility and the manner of applying these results to the problem of presenting materials for learning in school settings. The most important restriction on the scope of application of the present results is that research to date warrants generalization only to those kinds of school learning tasks that are isomorphic with the paired-associates paradigm. Runquist and Hutt (36), for example, report that high-school students learn verbal concepts more rapidly when the materials are represented verbally than when they are represented pictorially. The question of the possibility of applying the present results to school learning requires an answer that is sensitive to practical as well as to scientific constraints. The most direct implication of the demonstrable superiority of the pictorial mode is that relevant curricular materials presently available in printed form should be converted to a pictorial form. Although such a conversion would not be impossible, considerable resistance might well be expected. Alternatively, it is of interest to consider the suggestion that learners themselves be trained to make covert pictorial responses to printed materials. Such a program would not only avoid the difficulties involved in reconstructing current curricular materials, it would also better equip the learner to engage in efficient acquisition regardless of the character of the content he is asked to learn. A decision as to the feasibility of such a program awaits empirical evaluation.

The second kind of question is directed at the issue of choosing an explanation for the differences observed. Data reported by Wimer and Lambert (44) suggest that, for college-age Ss, the greater difficulty presented by the task of learning word-trigram than by that of learning object-trigram pairs is due to the greater intralist similarity among the former and not to differences in meaningfulness. Nevertheless, for Ss as young as those who participated in the present study, word and picture stimuli may differ in meaningfulness as well as in intralist similarity.

The facilitory effect of presenting pairs in the context of sentences appears quite robust across differences in populations and differences in materials. Again, however, the task of explanation remains to be accomplished, and a clarification of the facts as to the effects of connective form class is relevant to this task. The striking differences observed between the third- and sixth-grade samples in the way contextual strings affected the learning of pictorial and printed pairs invites speculation. In the third-grade samples, the relationship between connective form class and amount learned was markedly linear and consistent across materials, as if each of the kinds of learning aids added a constant increment to performance. For sixth-grade Ss, however, the preposition connectives appeared to be functionally equivalent to the verbs in producing superior learning of the word pairs and, pictorial presentation, with only a conjunction string context, seemed sufficient to promote learning as efficient as that produced by preposition strings in the third-grade samples. Loosely speaking, it was as if the sixth-graders' threshold for engaging in facilitory processes was lower than that of the third-graders. If this is true, it suggests again the possibility that children might be trained not only to make covert pictorial responses to printed materials but also to cast disparate learning elements in the mold of sentential structure.

Experiment IX: Verbal and Pictorial Elaboration

Experimental analysis of verbal facilitation has proceeded further than that of pictorial facilitation and this discrepancy has retarded examinations of possible relationships between these two methods of promoting efficient learning. The Rohwer (33) experiment designed to isolate the properties of sentences necessary for facilitating the learning of paired nouns revealed a form-class effect such that learning was most efficient with verb connectives, less (but not significantly so) with prepositions and least with conjunctions. Indeed, conjunction connectives produced no more rapid acquisition than that produced by the simple presentation of the noun pairs alone. Thus it was established that the manipulation of a verbal factor, namely, connective form class, was systematically associated with variations in the amount learned.

The question whether or not comparable effects could be produced by manipulating an equivalent pictorial factor remained unanswered. It is possible to conceive of visual translations of each of three kinds of strings used by Rohwer (33) such that those strings would qualify as descriptions of what could be seen in the visual translations. In the case of such materials, the question would be whether or not the manipulation of the verbal factor and the comparable pictorial factor would produce parallel differences in the amount learned. Reese (32) reported a PA experiment in which the design and the materials approximated those proposed here. The results were that the learning of paired pictures by young children, between 2 and 7 years of age, was increased by both verbal descriptions of interactions involving the two items in each pair ("Chicken carrying flag") and visual depiction of such interactions. The direction of the differences obtained was such that the verbal descriptions appeared somewhat but not significantly more efficacious than the visually depicted interactions. Since the visual materials consisted of line drawings, however, it is possible to argue that the difference between the two visual conditions was not as large as that between the two verbalization conditions, that is, action episodes cannot be represented literally in line drawings.

The purpose of the present experiment was to make an equitable comparison of the facilitory effects of verbal and visual methods of representing the relationship between the two pictorially presented objects in each of a list of pairs. Within each of the two facilitory methods, the differences among conditions were more finely graded than has been the case in previous research. A developmental study in which the factorial combination of the experimental variables was replicated at three grade levels was decided upon in order to permit an examination of the possibility of an interaction between the primacy of verbal and visual modes of representation and age. Even though Reese (32) found no such interaction it was of interest to determine whether or not this result would hold in the case of the kind of visual materials used in the present investigation.

Method

Subjects. A total of 432 children served as Ss in the experiment. Of the total, 144 were drawn from each of three elementary schools serving the same general middle-class residential area. Within each school, 48 children were randomly drawn from all of the classes at each of three grade levels, first, third, and sixth, and were randomly assigned to the 12 experimental conditions, four children to each condition.

Materials and design. All Ss were asked to perform on the same task, namely, that of learning a list of 24 pictures of paired objects by a pairing-test method. Aside from Grades, the two other principal factors in the design concerned (a) the character of the pictorial representations of the two objects in each pair (Depiction), and (b) the character of the verbal description of the two objects in each pair (Verbalization).

The materials were constructed in a sequence of steps. First, a large number of high-frequency nouns was selected, subject to the principal restriction that each should be the name of an object either small enough itself to be easily accomodated in a 4 x 4 x 4-foot photographic set, or capable of being represented by a model of restricted size. Out of the entire set of nouns 24 subsets of two nouns each were formed by a process that was random except for the requirement that a meaningful, grammatical sentence of the form article-noun-verb-article-noun could be constructed for every pair of nouns. These sentences constituted the Verb level of the verbalization factor. Materials for the Preposition and Conjunction levels were derived by substituting prepositions and coordinate conjunctions, respectively, for the verbs in the initial strings. The fourth level of the Verbalization factor, Control, consisted simply of the noun pairs themselves. A complete list of the verbal materials appears in Table 13 on page 56.

With respect to Depiction, the materials for the pairing trials were presented pictorially in one of three ways corresponding to each of the three kinds of contextual verbal strings already described. The nature of the correspondence was that the pairs of objects were photographed in such a way as to constitute visual translations of the three kinds of strings. In all three pictorial conditions, images of the pairs of objects were recorded on 16-mm. black and white motion picture film. The pairs of objects were photographed against a background and foreground of grey cloth. In the first of the depiction conditions, Still, the two objects in each pair were simply placed side by side on the set and photographed. In the second condition, Locational, the two objects in each pair were oriented spatially with respect to one another in a manner consistent with that described by the corresponding prepositional phrase. In the third condition, Action, the pairs of objects were photographed while they were involved in the movements prescribed by the verb strings. In the case of some pairs, it was possible to use the technique of continuous action photography whereas for other pairs, single-frame animation was necessary. The same objects were photographed in all depiction conditions and the duration of the film segments for every pair was four seconds. The test-trial materials were identical for all conditions, that is, 24 4-sec. segments of film bearing the images of each of the first-named objects in every pair. Four different random orders of pairing-trial and four different random orders of test-trial materials were formed so that any given order was never repeated during learning.

In sum, the design was a 3 x 4 x 3 factorial in which the independent variables were: Grades (1 vs. 3 vs. 6); Verbalization (Control vs. Conjunction vs. Preposition vs. Verb); and Depiction (Still vs. Locational vs. Action). In addition, the design was entirely balanced with respect to schools and experimenters (Es) of whom there were two, both male graduate students.

Procedure. The task was administered to Ss individually according to a pairing-test method for a total of four pairing and four test trials. Instructions informed the Ss as to the procedure that would be followed and asked them to study each of the pictures of paired objects as they appeared on the screen and to listen to the E's description of the objects in order to learn which objects were presented together. One example was given orally, without pictorial support, the Ss were told that they would be asked to provide the name of the missing object in each pair when shown the other object that had originally appeared with it. During all pairing trials, the appropriate pictorial materials were presented on a beaded screen by means of a movie projector and as each pair appeared, E read aloud the appropriate verbalization. On the test trials, E named each object as it appeared on the screen and recorded Ss' responses which were given orally. Consider, for example, the procedure followed for the Ss assigned to the Verb-Action condition. After an S was seated and the instructions were read to him, the film projector was started. A succession of 24, 4-sec. film segments was projected on the screen. Two objects appeared in each segment and in every one of these, the two objects were involved in an action episode (e.g. in one segment a dog walked to a gate and closed it). As each segment appeared on the screen, E uttered a sentence that described the episode in view (e.g. "The DOG closes the GATE."). These 24 segments of film and the accompanying verbalizations constituted the pairing trials during which Ss made no overt responses. Each pairing trial was followed after a 4-sec. interval by a test trial. The test trials consisted of the successive presentation of another 24, 4-sec. segments of film, each of which bore the image of one of the objects from each pair. As soon as an object appeared on the screen, the E uttered its name aloud (e.g. "dog") and the S attempted to recall and utter the name of the other member of the pair before the next picture appeared on the screen. This same procedure was followed in all conditions except for the manipulation of the character of the verbalizations uttered and the pictures shown. On both pairing and test trials, each item was visible for 4 secs; the inter-item interval was 1 sec.; and the inter-trial interval was 4 secs.

Results

An initial inspection of the data revealed the striking result that learning in all conditions was extraordinarily rapid. For all Ss the mean numbers of correct responses given on trials 1 through 4 were, respectively, 12.70, 18.93, 21.41, and 22.42 out of a possible 24. The pictorial mode of presenting PAs to children, as represented in the present experiment, in comparison with the mode of printed words, is apparently responsible for the observed ease of acquisition (See Experiment VIII).

For the purpose of examining the comparisons of principal interest, learning was indexed in terms of the total numbers of correct responses made on the four test trials. In Table 15, the results are presented as a function of Verbalization and Depiction

Table 15
Mean Numbers of Total Correct Responses as a Function of Verbalization and Depiction

	Verbalization				
Depiction	Conj.	Prep.	Verb	Control	All
Still	67.64	69.80	77.64	70.44	71.40
Locational	73.84	74.76	77.44	77.12	75.80
Action	80.24	78.32	81.00	77.12	79.16
All	73.92	74.28	78.68	74.92	75.44

conditions. Analysis of variance of these data (See Appendix I-1) revealed a significant main effect associated with differences in grade level, $\underline{F}$ (2,396) = 28.74, $\underline{p} < .01$. The mean numbers of total correct responses were 71.17 for the Grade 1 sample, 76.14 for Grade 3, and 79.04 for Grade 6. Individual contrasts evaluated by the Tukey method showed that each of the two ordered differences between grades was significant.

The main effect of Verbalization was significant, $\underline{F}$ (3,396) = 6.58, $\underline{p} < .01$, as were the main effect of Depiction, $\underline{F}$ (2,396) = 27.66, $\underline{p} < .01$, and the interaction of Verbalization and Depiction, $\underline{F}$ (6,396) = 2.38, $\underline{p} < .05$. Individual contrasts within the Verbalization main effect revealed that the only reliable differences were those between the Verb condition and each of the others. Relative to the Naming Control, only verb strings produced facilitation of learning. This result contrasts with previous research where the learning materials used have been printed nouns rather than pictures; preposition strings have regularly produced performance more similar to that produced by verb strings than to that produced by conjunction strings or by control conditions. Within the main effect of depiction, the order of means conformed to the outcome expected and each of the two comparisons of interest was significant; more was learned with Action pictures than with Locational and more was learned with Locational than with Still.

Inspection of the means in Table 15 indicates, and tests of individual comparisons within the interaction of Verbalization and Depiction confirm, that either verb strings, or locational pictures, or action pictures are sufficient to produce facilitation of PA learning. The effects produced by each of these three conditions of learning, in the absence of the others, are equivalent.

It is also noteworthy that the pattern of effects produced by the Depiction variable within the Control conditions in the present experiment is virtually parallel to the pattern of effects produced by the equivalent Verbalization variable when the learning materials were a printed-word version of the pictures used here (Experiment VIII).

None of the interactions of interest from a developmental viewpoint were significant. The $\underline{F}$ ratios for Grades by Verbalization, Grades by Depiction and Grades by Verbalization by Depiction were 1.09, 0.84, and 1.18, respectively. In summary, it seems clear that for all the populations sampled in the experiment, facilitation of PA learning can be obtained either with sentence descriptions of relationships between the two objects in each of several pairs or with equivalent pictorial translations of the relationships described.

Discussion

Given the present results, namely, that the pattern of facilitation produced by isomorphic verbal and pictorial factors is equivalent, two major issues remain to be examined. The first concerns the question whether covert processes underlying verbal facilitation are pictorial, whether covert processes underlying pictorial facilitation are verbal, or whether the two are independent of one another but co-dependent on some unknown third process. Evidence currently available does not permit a choice among these alternatives. Contrary to the conclusion suggested by Reese (32) there is no indication in the present results that verbal processes are primary. Indeed, if covert verbalization of pictorially depicted relationships were responsible for the efficacy of action pictures, more facilitation should have been produced by the verbalization than by the depiction factor but such was not the case. Furthermore, the magnitude of the depiction effect should have increased with age, since verbal facility presumably increases, but this trend was not obtained. An explanation in terms of covert pictorial processes is similarly contraindicated. In order to provide direct evidence as to the validity of one or another of these descriptions of the facilitory process, it might be fruitful to manipulate the depiction variable in a PA task given to $\underline{S}$s known to be unable to respond to pictures with efficacious verbal descriptions (e.g. deaf children) and to manipulate the verbalization variable with $\underline{S}$s known to be unable to produce their own visual translations of verbal descriptions (e.g. blind children). This method, however, has inherent problems with respect to the generalizability of results from exceptional populations to normal populations.

An alternative approach is that of examining PA performance as a function of the relationship between input mode and output mode. The question of interest may be phrased as follows: What is the character of the units in terms of which the material to be learned is stored? If these units are principally verbal, then when the input mode is held constant (verbal or pictorial) a verbal output mode should prove facilitory whereas if the units are principally pictorial, a pictorial output mode should be most facilitory.

Whichever kind of underlying process is involved, an implicit difficulty is that of selecting principles sufficient to explain the phenomena of verbal and pictorial facilitation of PA learning. On the verbal side, for example, empirical tests have produced evidence that contradicts hypotheses to the effect that verb strings facilitate acquisition by reducing nominal intralist similarity or by imposing increased constraint on the response term. Adequate explanatory terms, much less adequate explanations, have not yet been proposed.

The second major issue concerns the failure of the present experiment to detect developmental differences in the relative efficacy of verbal and pictorial modes of facilitation. Two features of the design make it impossible to give a definitive answer to the question of whether or not either of the two modes has developmental priority. First, and most obvious, is the fact that the youngest population sampled was that of first-graders. By this age, compensatory processes may have already developed to the point that they obscure the primacy of either the verbal or the pictorial mode. The second feature of the design relevant to the developmental issue is that no provision was made for independently assessing the Ss' capability of responding covertly to the learning materials nor for identifying the nature of such responses if they were made. Methods for accomplishing these ends would contribute substantially to further progress in resolving the issues.

This experiment marks the last of those studies to be reported dealing solely with the explication of the phenomena of elaborative facilitation. Additional light may be shed on these phenomena, however, by the results of the next set of experiments to be reported, namely, those dealing with elaboration and learning proficiency.

Elaboration and Learning Proficiency

Experiment X: Grade Level, School Strata and Learning Proficiency

The present experiment was performed in order to evaluate hypotheses suggested by the juxtaposition of two rather disparate topics of current research interest: elaboration and learning efficiency; and, group-related differences in learning proficiency. Results of research on the former topic (See, e.g., Experiment IX) indicate that two kinds of facilitory conditions have been isolated: verbal and pictorial. In connection with the second topic of pertinence to the present study, namely, group-related differences in learning proficiency, it has been shown repeatedly that when learning proficiency is measured in terms of performance on standardized tests of school achievement or on commonly used tests of intelligence, children from schools serving middle- and upper-income populations are superior to children from schools serving lower-income populations (e.g. 3, 43). It remains to be established whether or not the deficiencies in what and how much children from low-strata schools have learned are related to concomitant deficiencies in the performance of such children on tasks that demand new learning. Results reported by Semler and Iscoe (37) suggest that such a relationship may indeed hold. On a PA task, five- and six-year old white children learned more efficiently than Negro children from relatively lower-strata schools. Little difference was found for older children from the two groups.

One of the purposes of the present experiment was to assess the generality of the Semler and Iscoe findings for a different PA task and for groups distinguished primarily in terms of school strata rather than in terms of race. A second purpose was to determine whether or not the deficiency in PA learning expected to appear among young children from low strata schools could be ameliorated by presenting PAs under conditions known to facilitate learning in children drawn from upper-strata schools.

Method

Subjects. The total sample of 432 children was drawn from three grade levels (first, third and sixth) in two kinds of schools distinguished by the characteristic performance of their students on standardized tests of achievement and aptitude. Half the Ss were drawn from schools where test performance was low. Available information about the six populations from which the samples were selected is presented in Table 16. In addition to discrepancies in test performance, the high- and low-strata school populations differed in other ways associated with the distinction between "advantaged" and "disadvantaged" areas. For example, the modal occupational category of fathers of students in the high strata schools was Professional whereas that of fathers of students in the low strata schools was Semi-skilled or Unskilled Manual. In sum, the two populations were selected because of the contrast between them with respect to the learning proficiency of their students as assessed by standardized test performance and with respect to other characteristics often presumed to be related to the success of children in school learning.

From the total population of children within each grade level of the high- and low-strata schools, 2 Ss were selected and assigned randomly to one or another of the six experimental conditions such that each cell of the design was comprised of 12 Ss.

Materials and design. In addition to Grades and School Strata, the principal factors in the 3 x 2 x 3 x 2 factorial design were

Table 16
Mean Chronological Ages and Stanford Achievement Test
Grade-Equivalent Quartiles for Grades 1, 3, and 6
of the Two School-Strata Populations

Grade	School Strata	Mean CA (Years)	Stanford Achievement Test					
			Primary I, Form W					
			Reading					
			Q_1	Q_2	Q_3			
1	High	6.60	1.6	1.9	2.4			
	Low	6.93	1.4	1.5	1.6			
			Primary II, Form W					
			Word Meaning			Paragraph Meaning		
			Q_1	Q_2	Q_3	Q_1	Q_2	Q_3
3	High	8.57	No data available					
	Low	8.97	1.7	2.0	2.7	1.6	1.9	2.5
			Intermediate II, Form W					
			Word Meaning			Paragraph Meaning		
			Q_1	Q_2	Q_3	Q_1	Q_2	Q_3
6	High	11.60	5.7	6.9	8.4	6.6	7.3	8.1
	Low	12.06	3.8	4.4	5.1	3.2	4.2	4.8

Verbalization (Names vs. Phrases vs. Sentences) and Depiction (Still vs. Action). All Ss were asked to learn the same list of 24 pairs of familiar objects presented pictorially by a pairing-test method. The three Verbalization conditions differed only with respect to the character of the E's utterances during the pairing trials. As each pair was presented, E, using a prepared script, read either the names of the two objects (e.g. "DOG....GATE"), a phrase containing the names of the two objects (e.g. "The DOG and the GATE") or a sentence containing the names of the two objects (e.g. "The DOG closes the GATE."). The comparison of principal interest was that between Names and Sentence conditions but since the presentation rate was constant for all conditions, the Phrase condition was included to control for potential differences in rehearsal time during the pairing trials. Previous research (33) has indicated that conjunction phrases are adequate for this purpose since they do not bias performance while still providing a grammatical context to fill the pairing interval.

The second experimental factor, Depiction, consisted of two levels that differed with respect to whether the object pairs were presented in a manner consistent with the Name and Phrase verbalizations in the one case (Still) or in a manner consistent with the Sentence verbalizations in the other case (Action). The film materials were those used in Experiment IX.

In addition to the four principal factors in the design, the experiment was entirely balanced with respect to experimenters, of whom there were two, both male graduate students.

Procedure. The task was administered to Ss individually for a total of two pairing and two test trials. Instructions informed the Ss as to the procedure that would be followed and asked them to study each of the pictures of objects in order to remember which ones were presented together. One or more examples were given orally without pictorial support until Ss appeared to understand the task. During both pairing trials, the appropriate pictorial materials were presented on a beaded screen by means of a movie projector, and, as each pair appeared, E read aloud the appropriate verbalization. On the test trials, E uttered the name of each object when it appeared on the screen and recorded Ss' responses which were made orally. On pairing and test trials, each item was visible for four secs.; the inter-item interval was 1 sec.; and, the inter-trial interval was 4 secs.

Results

Learning was measured in terms of the total numbers of correct responses made on the two test trials. The mean numbers of correct responses obtained by the two Es were very close (32.09 vs. 31.61) and since a simple analysis of variance revealed that the difference was not reliable ($F < 1$) this variable was ignored in the remaining treatment of the results.

A four-way analysis of variance was applied to the data produced by the factorial design (See Appendix J-1). As expected, the main effect of Grades was significant, $F(2,396) = 20.51$, $p < .01$, such that the amount learned by sixth graders (33.92) was larger than that learned by third graders (32.16) which, in turn, was larger than that learned by first graders (29.48). The variance associated with School Strata, however, was not significant, $F < 1$; as an inspection of Table 17 suggests, the average performance of children from Low-strata schools was virtually the same as that of children from High-strata schools. The main effect of Verbalization was significant, $F(2,396) = 17.58$, $p < .01$, and a comparison of the three component means revealed that the effect was comprised entirely of the superiority of the Sentence condition over both the Phrase and the Name conditions. Within Depiction, Action was associated

Table 17
Mean Numbers of Correct Responses as a Function of Strata, Depiction and Verbalization

		Verbalization			
Depiction	School Strata	Name	Phrase	Sentence	Total
Still	High	27.36	26.66	33.14	29.04
	Low	26.48	25.92	33.72	28.70
	Sub-Total	26.92	26.29	33.43	28.88
Action	High	33.00	35.08	35.72	34.60
	Low	36.48	34.30	34.36	35.04
	Sub-Total	34.74	34.69	35.04	34.82
	Total	30.83	30.49	34.24	31.85

with more correct responses than was Still, $\underline{F}$ (1,396) = 108.56, $\underline{p} < .01$.

Within the analysis of variance, the tests that are critical for an evaluation of the experimental hypotheses are: the interaction of Strata with Verbalization and Depiction; and, the interaction of Grades, Strata, Verbalization and Depiction. Before the results of these tests are reported, consider the core interaction, Verbalization x Depiction, ignoring the classification variables of Strata and Grades. The relevant means are presented in Table 17. In agreement with our expectations, this interaction was significant, $\underline{F}$ (2,396) = 14.51, $\underline{p} < .01$, and it was located entirely in the difference between those conditions designed to be facilitory and those not so designed. That is to say, the amount learned in the Name-Still and the Phrase-Still conditions was significantly smaller than the amount learned in any one of the Sentence or Action conditions. None of the other pair-wise contrasts was significant. Sentence verbalizations and visual translations of those sentences produced equivalent levels of performance. Similarly, Name and Phrase conditions were assoicated with equal amounts of learning, indicating that the increased opportunity for rehearsal provided in the former was of no advantage.

Turning now to the interactions of critical interest, the analysis revealed that neither was significant. The form of the interaction of Verbalization and Depiction was comparable for all *Ss*, whether they were sampled from Low-strata schools or from High-strata schools, $F\ (2,396) = 2.67$, $p = > .05$. An examination of the means shown in Table 17 suggests, and an application of the Scheffé method confirms, that the only difference between Strata lies in the marginal superiority of the Low-Name-Action group over the High-Name-Action group, $p = > .05$. Contrary to our prediction, *Ss* from Low-strata schools performed no less well than *Ss* from High-strata schools in both the customary conditions of PA learning and in the facilitory conditions. Furthermore, the form of this three-way interaction was comparable for all Grades, that is, the four-way interaction was not significant, $F < 1$. In sum, the present experiment produced no evidence in support of the assertion that children from Low-strata schools learn PAs less efficiently than children from High-strata schools.

The only other significant term in the analysis of variance was the interaction of Grades and Verbalization, $F\ (4,396) = 3.70$, $p < .01$. The form of this interaction was such that the difference between Name and Sentence conditions was larger in the first than in the third and sixth grades. The only supportable interpretation of this interaction, in view of the fact that the form of the Verbalization by Depiction interaction was equivalent for all Grades, $F\ (4,396) = 1.26$, $p > .25$, is that the facilitory effects of Sentence verbalization was obscured in the higher grades by the effects of the Depiction conditions.

Discussion

The relatively high degree of learning proficiency observed among children from Low-strata schools is at once the most puzzling and the most promising aspect of the present results. Evidence available before the learning task was administered led to the expectation that such children would be distinguished by their inability to engage successfully in new learning. If performance on standardized tests of school-related achievement is taken as an index of how much children have been able to learn up to the time of examination and if, as was the case in the present study, two groups of *Ss* are equated for chronological age but still differ markedly in their test scores, a possible inference is that the members of the low-scoring group are deficient in learning ability. Obviously, this argument is too simple-minded in the sense that equivalence of chronological age does not necessarily imply equivalence of opportunity for relevant learning. Nevertheless, the teachers of the children from the Low-strata schools corroborated the simplistic inference indicated by standardized test performance in describing their students as being slow to learn and difficult to teach. Furthermore, the performance of Low-strata children on school-related tests of achievement is predictive of subsequent success in school learning. Thus it seems unwarranted to conclude that standardized test performance is unrelated to learning proficiency and yet the results of the present experiment seem to imply just this conclusion.

Two interpretations of the discrepancy between test and learning task performance remain to be considered. The first is that PA learning is unrelated to the kinds of learning in which a child must engage in order to perform successfully in school and on tests of school achievement. Although this interpretation cannot be discounted, we are inclined to dismiss it on the assumption that a careful description and analysis of the kind of learning teachers attempt to induce in students, especially in first-grade curricula, would reveal numerous instances of similarity to the PA paradigm. A second and, in our view, a more likely interpretation of the discrepancy is that it occurs because of pronounced differences between the conditions of learning that are characteristic of the classroom and those that are characteristic of the laboratory.

In brief, three kinds of such differences may be distinguished: First, greater control of the focus of the child's attention is achieved in the laboratory than in the classroom by (a) administering the learning materials individually rather than to groups, and, in the special case of the present study, by (b) presenting the elements to be learned in a form that elicits the attention of the child. Second, the requirements of the child's task are explicitly detailed to a much greater extent in the laboratory than in the classroom. Third, in the laboratory case, the information necessary for the child to make a judgment about the adequacy of his performance is inherent in the learning materials themselves whereas in the classroom, such information is typically made available only in the teachers reaction to the child's behavior and not within the boundaries of the task itself. Whether or not these differences between the conditions of learning in the classroom and in the laboratory are responsible for the discrepancy between the performance of Low-strata children on standardized tests and their performance on learning tasks, it should be noted that the higher incidence of success in the laboratory then in the classroom, at least in the present study, may itself reinforce the behaviors that lead to efficient learning.

Aside from the foregoing remarks that are clearly and admittedly speculative, the results of the present experiment demonstrate empirically that the efficiency with which children, whether they are drawn from Low- or High-strata schools, learn PAs can be notably affected by the manner in which the items are presented. Both the verbal condition of sentence contexts and the pictorial condition of action episodes proved facilitory for all groups of $\underline{S}$s. Thus the relevance of the results to the problems of the design of educational procedures and materials is by no means confined to upper-strata populations.

The present results diverge from those reported by Semler and Iscoe (37) only with regard to the performance of the first-grade or six-year old samples. This divergence may be attributable either to task differences or to differences in the way populations were defined in the two studies. More specifically, one possibility is that the method of presenting learning materials used in the present experiment may have elicited more constancy of attention from Low-strata six-year olds than that used by Semler and Iscoe. Furthermore, attention was only required for the duration of two trials in the present study in contrast to the twelve trials administered in the previous one.

One further obstacle remains before the inference that low-strata children are proficient learners can be accepted, even for the limited number of instances of learning that conform to the PA paradigm. This obstacle is raised by the suspicion that the task used in the present experiment was simply not difficult enough to permit the detection of a difference between proficient and inept learners. This suspicion persists and can be dismissed only by direct evidence to the contrary, even though internal evidence from the present study partially contradicts it. That is to say, if the task were too easy, the between Ss variance should have been quite small but it was not. Indeed, this source of variance was sufficiently large to yield an F ratio of 6.30.

Experiment XI: Familial vs. Cultural Retardation

One of the purposes of the present experiment was to evaluate the hypothesis that the task used in Experiment X was not sufficiently difficult to reveal differences in learning proficiency as between fast and slow learners. The method chosen for assessing this assertion was that of administering the task to a sample of persons known to be slow learners, namely mentally retarded adults. If such Ss learn as rapidly as normal Ss, the implication would be that the task was, indeed, too easy for use in distinguishing slow from fast learners.

The study was also addressed to a problem of current interest with respect to two other kinds of issues: that of distinguishing between familial and cultural retardation; and that of describing the nature of familial retardation. The problem itself concerns an assessment of learning proficiency, as indexed by performance on the PA task described in connection with Experiments IX and X, among samples drawn from three populations: institutionalized retardates; low-strata school children; and, high-strata school children.

As measured by performance on tests of intelligence or of school achievement, the proportion of retarded children (IQ range 50 to 70) among low-strata populations is larger than that among high strata populations (5). The question is whether or not scores on such tests reflect underlying learning proficiency as accurately for the former as is the case for the latter. If not, then intelligence tests cannot be relied upon as singularly sufficient devices for the intellectual classification of children. And, research to date appears to indicate that the answer to this question is, indeed, no. Rapier (31), for example, reports that the correlations between IQ and learning proficiency(as measured by performance on serial and PA tasks) are substantially lower among low-strata children ($\underline{r}$ = .22, .16) than among high-strata children ($\underline{r}$ = .43, .52).

The diagnostic problem posed by such results is that of distinguishing among retarded children (those whose performance on intelligence tests yields a low IQ) persons who have learned relatively little during a given number of years because they are true slow learners (familial retardates) from those who have learned equally little because of a corresponding deficiency in their opportunity to learn (cultural retardates). One potential solution to the problem is the use of learning tasks as diagnostic instruments in conjunction with standardized tests of intelligence. But before this solution can be recommended, it is necessary to show that groups of retardates suspected to be of the cultural variety (CRs) perform better on such learning tasks than groups of retardates known to be of the familial variety (FRs) when the two are equated for mental age (MA).

This stipulation raises the second issue for which the present study has relevance, namely, that of the nature of familial retardation. For, if Zigler (47) is correct, groups of normal learners and of FRs, equated for MA should not perform differently on learning tasks when care is taken to equate for motivational factors. As advanced by Zigler (47) a general developmental theory of familial retardation appears to consist of three principal assertions. The first is that FRs do not constitute a population that is distinct from that represented by the normal distribution of intelligence; rather, they represent the lower end of that distribution, differing only in the rate and upper limit of cognitive development achieved (p. 294). Secondly, Zigler argues, this assertion implies that FRs and normals, equated for level of cognitive development, as is roughly the case in equal-MA comparisons, should be characterized by the same kinds of cognitive functioning. Finally, an even stronger assertion is made; that given equal-MA comparisons, not only the same kinds of cognitive functioning but also the same levels of performance should be observed in FRs and normals.

Accepting the first of these principal assertions, the present experiment was designed, in part, to test an hypothesis consistent with the second assertion and to test another hypothesis contradictory to the third. The position taken here is that a general developmental theory can be adopted while rejecting the prediction that equal-MA comparisons should yield equal levels of performance by FRs and normals on cognitive tasks. Evidence already available is consistent with such a position. Jensen (12) found that normal school children performed at a higher level than institutionalized retardates (characterized by no known organic defect) on both a serial and a PA learning task. It must be admitted that in terms of Zigler's analysis this study confounds the variables of intelligence and institutionalization thereby rendering the conclusion indefinite. Another study (31), however, does not have this limitation. A comparison was made of serial and PA learning efficiency as between equal-MA high- and low-strata children where both samples were retarded and non-institutionalized. The latter group performed significantly better than the former on both learning tasks, indicating that equal MAs do not imply equality of learning proficiency. Furthermore, the low-strata retarded group learned as efficiently as equal-CA groups of both low- and high-strata children, suggesting that learning tasks might be quite useful in conjunction with intelligence tests in distinguishing between FR and CR.

The design of the present study permits another examination of this issue, incorporating the possibility of comparisons among samples of institutionalized retardates, low-strata children, and high-strata children. The experiment was also designed to assess the assertion that the same kinds of cognitive structures are operative for normals, FRs, and CRs. In Experiment X it was found that high- and low-strata elementary school children (grades 1, 3 and 6) not only performed at the same level but responded similarly to various experimental conditions under which the task was presented. That is to say, the Depiction factor (Still vs. Action pictures of each pair) and the Verbalization factor (names of the two objects in each pair vs. phrases containing the names vs. sentences containing those names) were associated with the same kinds of performance differences in both samples. In all cases, action pictures and sentence descriptions produced more efficient learning than any of the other conditions. From these results it may be inferred that the same kinds of cognitive structures are available to low- and high-strata children within the age range sampled, if it is granted that response to the experimental conditions represents a valid index of some corresponding cognitive structures. On this assumption, the present experiment examines this same issue for younger children and for institutionalized retardates as well.

Method

Subjects. The total sample of 432 was comprised of 48 Ss drawn from each of nine different populations: kindergarten (K), first, third and sixth grades in schools serving middle-class residential areas; grades K, 1, 3 and 6 in schools serving lower-class residential areas;[3] and, retarded adults, having no known organic defects, in a public institution for the mentally retarded. Within each sample, equal numbers of Ss were assigned randomly to the four experimental conditions. Chronological age information for each of the samples is presented in Table 18. Information as to mental age is available on three of the samples: lower-strata K, upper-strata grade 3, and retarded adults. This information was obtained from the files of the respective institutions in the latter two cases: upper-strata third graders had been administered the Kuhlmann-Anderson; mentally retarded adults had been administered the Binet. For the purposes of the present study the Binet was administered to the sample of low-strata K children. The mean MA of the retarded adults and the upper-strata third-graders was equivalent ($\overline{MA}$ = 9.66 and 9.61, respectively) whereas that of the lower-strata K group was considerably below this ($\overline{MA}$ = 4.70). Thus, both an equal-MA comparison and an unequal-MA comparison favoring the retarded adults could be made in terms of performance on the PA task.

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[3] The low- and high-strata, first-, third- and sixth grade samples are those described in connection with Experiment X. The

Table 18

Mean Chronological Age of the Samples as a Function of Population Membership

	Grade				
Strata	K	1	3	6	Retardates
High	5.32	6.60	8.57	11.60	25.56
Low	5.31	6.93	8.97	12.06	

Materials and design. All Ss were asked to learn the same list of 24 pictorial PAs, those described in Experiment X. Two of the films were used; in one, each pair of objects had been filmed while engaged in a short action episode (e.g. a sequence showing a DOG walking to a GATE and closing it); in the other film the two objects in each pair were stationary when filmed. Thus, the first experimental factor was Depiction (Action vs. Still).

The second experimental factor, Verbalization, consisted of two levels: Names vs. Sentences. In the former, as each PA was presented during the pairing trials, E uttered aloud the names of the two objects in view, whereas, in the latter, he uttered a sentence containing those two names. These verbalizations were the same as those used in Experiment X. In sum, the design was a 9 x 2 x 2 factorial with independent groups in which the principal factors

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observations made on these samples have been reanalyzed in conjunction with those made on the three additional samples described here.

were Groups, Depiction and Verbalization.

Procedure. The task was administered individually to each *S*. The instructions described the pairing-test procedure and encouraged *Ss* to attend to each of the pairs as it was shown and to the *E*'s accompanying utterance during the pairing trials. It was explained that the test trials would consist of the successive presentation of one of the objects from each pair and that the *S*'s task was to recall and utter the name of the missing object. Examples were given orally to illustrate the procedure.

The films were presented on a beaded screen by means of a 16 mm. movie projector; accordingly the testing room was dimly illuminated. During the pairing trials, *E* read the appropriate verbalization as each PA appeared on the screen and during the test trials he read the name of the exposed object from each pair as it appeared on the screen. The *S*'s task was to utter the name of the missing object from each pair immediately after *E* named the visible object. On both pairing and test trials, the exposure interval was 4-secs., the interitem interval was 1 sec. and the intertrial interval was 4-secs. For all *Ss* the task was terminated after two complete trials.

Results and Discussion

Learning was measured in terms of the numbers of correct responses made on the two test trials. These scores were subjected to analysis of variance of the type suggested by Winer (45) which permits the inclusion of a group extraneous to a balanced design in the overall analysis (See Appendix K-1). In the present case, that group is, of course, the institutionalized retardates. The principal sources of variance assessed were: Populations (retardates, vs. all other groups); Grades (K vs. 1 vs. 3 vs. 6); Strata (Lower vs. Higher); Depiction (Still vs. Action); and, Verbalization (Names vs. Sentences).

The results pertinent to an appraisal of the relationship between learning proficiency and subject classification variables are presented in Table 19. The main effect of Populations (P) indicated that the retarded group performed less well than all other groups combined, $F\ (1,396) = 103.22$, $p < .01$. Similarly, the main effect of Grades (G) was significant, $F\ (3,396) = 32.07$, $p < .01$, and an application of the Scheffé method revealed that the performance of the sixth and third grade samples did not differ significantly but that both were superior to the first grade group, which, in turn, was superior to the kindergarten sample. Neither the main effect of Strata (S), $F < 1$, nor the interaction of S x G, $F\ (3,396) = 2.04$, $p > .05$, was significant. Comparisons of the performance of the retarded group with each of the other samples were made by means of Dunnett's method. Learning was more efficient in every one of the samples of children than in the sample of institutionalized retardates.

Table 19
Mean Numbers of Correct Responses per Trial
as a Function of Population Membership

	Grade					
Strata	K	1	3	6	Total	Retardates
High	13.54	15.06	16.62	16.77	15.50	9.96
Low	11.82	14.88	17.14	17.12	15.24	

Note that this result holds for the lower-strata kindergarten comparison, a sample in which the mean MA was much lower than that of the retardates, as well as for the equal-MA comparison with the upper-strata third grade sample.

In view of the latter results, the assertion that normals and retardates of the same MA do not differ in level of intellectual performance seems clearly invalid. It might be argued that the inferiority of the retarded group vis-a-vis the upper-strata third-grade sample can be accounted for in terms of differences in motivational and emotional factors rather than in intellective factors. Close examination, however, indicates that this argument does not hold for the observed inferiority of the retardates to the lower-strata samples. In advancing the case for the attribution of performance differences to motivational factors, Zigler (47) relies mainly on the notions of social deprivation and failure expectancy, both of which are higher in retarded than in upper-strata samples. But both a history of social deprivation and of failure, especially on cognitive tasks, are characteristics of lower-strata children as well as of retardates. Indeed, it might be presumed that lower-strata children have a more pronounced history of failure, at least on tests and formal educational tasks, than do retardates. Accordingly, an explanation of the inferior performance of the retardates on the present PA task in terms of motivational factors is not at all persuasive. In contrast, the results are consistent with the assumption that familial retardates are inherently slow learners. If so, this characteristic rate of learning would be expected to appear in their performance on learning tasks as was clearly the case in the present experiment.

Another implication of these results is that a learning task such as that used in the present study is of potential utility in distinguishing cultural from familial retardates among those who score in the retarded range on tests of intelligence. Obviously, the present results are not sufficient to warrant an immediate recommendation in this regard for all of the tasks of test construction and evaluation remain to be done. Nevertheless, the results suggest that such an effort has considerable promise, and lay to rest the hypothesis that the present PA task is too easy for use in distinguishing slow from proficient learners.

It still remains to examine the results relevant to the issue whether normals and retardates are characterized by the same types of cognitive structures. For this purpose the appropriate tests are those involving the interactions of the experimental conditions with the variables of subject classification. Apart from such interactions, the effects of the experimental conditions themselves were substantial: the main effect of Verbalization (V) yielded F (1,396) = 22.63, $p < .01$; that of Depiction (D), F (1,396) = 48.18, $p < .01$; and, the interaction, V x D was associated with an F (1,396) = 18.37, $p < .01$. The relevant means for these and the following effects are presented in Table 20.

Table 20

Mean Numbers of Correct Responses per Trial as a Function of Populations, Verbalization and Depiction

	Conditions			
	Names		Sentences	
Populations	Still	Action	Still	Action
High Strata	13.10	15.73	15.88	17.29
Low Strata	12.18	17.12	15.59	16.07
All Children	12.64	16.42	15.73	16.68
Retardates	7.71	11.29	10.21	10.62
Totals	12.09	15.85	15.12	16.01

No one of the three interactions critical for the assertion of similar cognitive structures in retardates and normals was significant. Indeed, all three, P x V, P x D, and P x V x D, yielded Fs < 1. This is to say that the pattern of facilitation produced by sentences and action pictures did not differ as a function of the contrast between institutionalized retardates and normal school children. The result is entirely consistent with what has been identified here as the second principal assertion of a developmental theory of familial retardation. Despite the data in the present results indicating that the two populations differ in level of performance, the kinds of cognitive structures involved in the two samples appear very similar.

Among the remaining tests in the analysis of variance, few yielded significant F ratios. None of the interactions involving Verbalization and subject factors were significant; the only one in excess of unity was Strata by Verbalization, $F\ (1,396) = 1.90$, $p > .05$. Similarly all of the interactions of Depiction with subject factors were associated with $Fs < 1$. Among all of the interactions of subject factors with V and D, simultaneously, only one exceeded unity, namely, S x V x D, and that one was significant, $F\ (1,396) = 5.24$, $p < .05$. An inspection of the means involved in this effect as presented in Table 20 and an application of Scheffé's method reveals that the interaction is significant only in the lower-strata samples. We have no explanation for this outcome and one should probably not be attempted until the effect is replicated.

Reflection about the results of the present experiment suggests the following interpretation. Among Ss who are classified accurately as familially retarded, even optimal conditions of learning, as represented by the PA task used here, are not sufficient to improve performance to the level of that observed in equal-, or lower-MA normals. In contrast, under these same conditions, the performance of lower-strata children, inaccurately classified as slow learners on the basis of standardized test performance, belies the assumption that they cannot be proficient learners. Finally, within the age and intelligence range sampled, all three populations appear to share the same kinds of cognitive structures and, thus benefit equally from facilitative conditions of learning.

Experiment XII: Economic Status and Learning in Pre-School Children

The results of Experiments X and XI were encouraging with respect to the notion of developing the pictorial PA learning task into the form of a test. There were also indications that it might be feasible to extend the age range to which the task had been administered downward as far as the three year old level. The present experiment represents an attempt to commence efforts toward both of these goals.

Test development is a long and complicated undertaking in which an important first step is to state clearly the objectives of the instrument envisioned. In the present case, the objectives are twofold: to construct a test that distinguishes between cultural and familial retardation; and, to design the test to yield reliable information as to the locus of elaborative deficits, if any, in children. The first of these objectives must await subsequent work. One of the purposes of the present experiment was to assess the possibility of adapting the pictorial PA materials in the service of the attainment of the second objective.

In the experiments reported thus far, it has been clearly established that learning efficiency can be improved by two specific means: verbal (sentence elaboration) and pictorial (action elaboration). Accordingly, it is of potential utility to induce children to adopt these elaborative strategies in order to improve their learning proficiency. But before children are subjected to training in elaboration, it is important to determine their present status with respect to learning proficiency and with respect to their ability to benefit from such training. In this regard, at least three potentially different kinds of children may be distinguished: those who already engage in the elaboration of materials to be learned and, therefore need little additional training; those who do not learn efficiently but who could not benefit appreciably from such training because of inherent deficiencies; and, those who do not learn proficiently but who could be trained to do so by means of engaging in elaboration. The latter category can be subdivided according to the type of elaboration most beneficial to member individuals, that is, verbal or pictorial elaboration. To accomplish these kinds of diagnoses, an instrument is needed that will appraise the child's performance under conditions of pictorial elaboration, verbal elaboration and no elaboration. In other words each child must be administered all of the experimental conditions described in Experiment XI: Still-Name, Still-Sentence, Action-Name, Action-Sentence.

The latter requirement necessitates a departure from the method followed in all of the studies reported heretofore. In these, independent group designs were used uniformly such that a given S was tested under only one of the experimental conditions. Consequently, no information is available from those studies as to the feasibility of a mixed-list design in which every S is administered the task under all conditions. The mixed-list design not only permits an evaluation of the intra-individual effects of the four experimental conditions but also yields an estimate of the reliability of individual differences in response to the two varieties of elaboration under study. An additional benefit of the mixed list design is that the relationship between learning efficiency and tested intelligence can be appraised since, in contrast to the independent groups design, all Ss are administered the same task. Thus with regard to the goal of test development, the aims of the present study were modest and preliminary: to examine the feasibility of a mixed-list design; to determine whether the pictorial PA task yields reliable individual differences in response to elaborative conditions; and, to estimate the degree of relationship between performance on this task and on an intelligence test.

The study has another set of aims related to the foregoing. These aims concern the issue of strata differences in learning proficiency in pre-school children. In the results of Experiment XI, there was the suggestion of a strata difference favoring the high-strata group in the kindergarten samples. In view of this it was of interest to determine whether this difference would appear more clearly in still younger Ss, namely, children of pre-school age. And, finally, it was of interest to estimate the degree of relationship between performance on a learning task and performance on an intelligence test for upper- and lower-strata children separately in this age range.

Method

Subjects. The sample consisted of 160 pre-school children varying in age from 36 to 65 months, all of whom were enrolled in nursery schools of the parent cooperative variety. Half of the Ss were from homes in which the modal occupation of the head of the household was "unemployed" whereas the modal occupation of the head of the household for the other half was "Professional-Managerial". All of the families in the former group (low strata) were receiving public welfare financial assistance at the time the study was conducted but this was not the case for any of the families in the latter group (high strata). Each of the strata groups was divided into subgroups of equal size according to the age of member Ss, such that the range in the younger groups was from 36 to 52 months while the age of Ss in the older groups ranged between 53 and 65 months. Thus, the design permitted an examination of relationships between two S characteristics, Strata and Age, and learning efficiency.

Materials and design. Each S was asked to learn a 20 item PA list by a pairing test method. The pairs were selected from the filmed 24 item list described in connection with Experiments X and XI. After an item analysis was performed on the results obtained in those two experiments with the full 24-item list, the four least desirable items were deleted from the task proper and used only as sample items in the present experiment. Two complete trials, two pairing and two test, were administered to each S.

All of the pairs were presented pictorially but each item in the list was presented under one or another of four different conditions: Name-Still, Name-Action, Sentence-Still, Sentence-Action. The twenty pairs were randomly divided into four sets of five items each and each set of five items was assigned randomly to one of the four conditions constituting one mixed list of items. Four such mixed lists were constructed such that each of the four sets of items appeared under each one of the four conditions. Thus, each of the four subsamples in the experiment, as previously defined in terms of age and strata, was further subdivided such that one-fourth of the Ss received one of the four lists, another fourth received the other list and so on, such that lists were balanced across groups. In sum, the total design was a six-way factorial, in which the principal factors were: Strata, Age, Lists, Verbalization, Depiction and Trials.

Both the visual and the auditory materials were recorded on videotape for each of the four lists so that the materials were constant for all *S*s in a particular list condition. Each of the tapes was presented on a Sony videotape recorder played through a Sony 10" black-and-white monitor.

Procedure. Each *S* was tested individually. After entering the testing room, he was seated in front of the monitor which was placed approximately at eye level. The white, female *E* read the instructions which informed the *S* that he was to learn a list of pairs in such a way that when presented with one of the objects from each pair he could recall the other. Immediately after the instructions were given, the practice task, consisting of one pairing and one test trial on four sample pairs, was administered. If an *S* did not respond or responded inappropriately during the test trial of the practice task the list was presented again to insure that the instructions had been understood. Otherwise, the one-trial practice task was followed by the administration of the first pairing trial of the 20-item PA list.

During each of the two pairing trials, the 20 PAs were presented at a 4-sec. rate. The two objects in a pair appeared on the screen of the monitor and at the onset of this image, the verbalization was presented through the speaker of the monitor. There was a 4-sec. interval between the pairing and test trials. Following this interval, one of the objects from each of the 20 pairs was presented at a 10-sec. rate. The stimulus member of the pair was visible on the screen for only 4-secs., however, such that there was, in effect, a 6-sec. inter-item interval. As the stimulus member of a pair appeared on the screen, its name was presented over the speaker and the *S* was to utter aloud the name of the object that had appeared with it on the pairing trial. This procedure was repeated for a total of two complete trials.

In addition to the learning task, each *S* was administered the Peabody Picture Vocabulary Test, Form B, during a separate session.

Results

Learning. Learning was measured in terms of the numbers of correct responses made on the two test trials. These data were subjected to analysis of variance in which trials and the experimental conditions of Verbalization and Depiction were repeated measures factors. (A summary of the analysis of variance is presented in Appendix L-1.)

In contrast to the results previously obtained, a clear difference in learning efficiency favoring the higher-strata children emerged in the present study, F (1,144) = 25.33, $p < .01$. The main effect for age was also significant, F (1,144) = 36.16, $p < .01$, such that the older children learned more rapidly than the younger.

The interaction of Strata and Age, however, was not significant, $\underline{F} < 1$. The results relevant to these tests are presented in Table 21. In general, our expectations were confirmed by these data;

Table 21
Mean Numbers of Correct Responses as a
Function of Strata and Age

	Strata		
Age	Higher	Lower	Total
Older	2.66	1.88	2.27
Younger	1.75	1.18	1.46
Total	2.20	1.53	

among pre-school age children, SES is related to learning efficiency as indexed by a PA task. The absence of a Strata x Age interaction is not surprising in view of the fact that sampling did not include six and seven year old populations among whom no strata-related differences have been found.

With regard to the experimental conditions, both the main effect of Verbalization, $\underline{F}\ (1,144) = 46.37$, $\underline{p} < .01$, and that of Depiction, $\underline{F}\ (1,144) = 13.35$, $\underline{p} < .01$, were significant; both sentences and action pictures facilitated the acquisition of the PAs. This result is, of course, consistent with what has been found among older children in experiments using independent group designs. Thus the feasibility of using the mixed-list design for investigating the effects of verbal and pictorial elaboration has been demonstrated and, of equal importance, the present results establish the utility of the present kind of PA task for the investigation of learning in very young children.

As can be surmised from an examination of Table 22, the interaction of verbalization and depiction was not significant, $\underline{F} < 1$, such that the effects of these two conditions of elaboration appear to be additive for children in the age range sampled. Note that *post hoc* comparisons among the means shown in Table 22, show that the facilitory effect of sentences, in the present samples, was larger than that of action pictures; the comparisons pertinent to this conclusion are those between the Naming-Still condition and the two conditions incorporating a single form of elaboration, namely, the Sentence-Still, and Naming-Action conditions.

The interaction of Strata with Verbalization, however, was significant, $\underline{F}\ (1,144) = 12.22$, $\underline{p} < .01$. The form of the interaction can be seen in Table 22, and an application of the Scheffé procedure

Table 22
Mean Numbers of Correct Responses as a Function of Strata, Verbalization and Depiction

	Verbalization					
	Naming			Sentence		
Strata	Still	Action	Total	Still	Action	Total
Higher	1.80	1.98	1.89	2.39	2.63	2.51
Lower	1.34	1.52	1.43	1.49	1.77	1.63
Total	1.57	1.75		1.94	2.20	

confirms that the higher strata children derive more benefit from sentence elaboration than do lower-strata children. The form of this interaction does not appear to vary as a function of age, that is, the Age x Strata X Verbalization interaction was not significant, $\underline{F} < 1$. As in the case of the main effect of Strata, the Strata x Verbalization interaction would be expected to disappear in age groups of six years and older.

In contrast to differences in the efficacy of verbal elaboration as a function of strata membership, pictorial elaboration apparently is equally efficacious for both higher and lower strata children, that is, the interaction of Strata with Depiction was not significant, $\underline{F} < 1$.

The remaining significant substantive effects involve the factor of Trials. The main effect of Trials was significant, $\underline{F}\ (1,144) = 402.76$, $\underline{p} < .01$, as were the interactions of Trials with Age, $\underline{F}\ (1,144) = 18.08$, $\underline{p} < .01$, and with Strata, $\underline{F}\ (1,144) = 12.51$, $\underline{p} < .01$. The means relevant to these effects are presented in Table 23. An application of the Scheffé method to the two interactions revealed that: the superiority of older children was greater on trial two than on trial one; and, the superiority of upper-strata children was greater on trial two than on trial one. The three-way interaction of Age, Strata and Trials, however, was not significant, $\underline{F} < 1$.

The remaining effects in the analysis of variance that were statistically significant all involved the factor of lists in interaction with one or a combination of the other variables. The differences associated with these effects derived from two sources: the first was that some sets of five items were more difficult, for one reason or another, than other sets; and, secondly, the same items served under different conditions on each of the four lists. The implication of this result is that considerable care must be

Table 23
Mean Numbers of Correct Responses as a Function
of Strata, Age and Trials

	Trials					
	1			2		
Strata	Older	Younger	Total	Older	Younger	Total
Higher	1.91	1.25	1.58	3.40	2.24	2.82
Lower	1.34	0.84	1.09	2.41	1.51	1.96
Total	1.63	1.05		2.91	1.88	

taken to equate item difficulty across experimental conditions when a mixed-list design is used in order to remove this undesirable source of variance. Note that the overall results reported above for the effects of experimental conditions are not affected by the lists interactions since item difficulty was balanced across the four lists.

Reliability. The results of the analysis of variance performed on the learning data also provide approximate estimates on the reliability of individual differences in performance on the PA task. The estimate of the reliability of individual differences in total score on the PA task was relatively high ($r = .846$). Although somewhat lower, the reliability estimates of individual differences in response to the two conditions of Verbalization and to the two conditions of Depiction were of acceptable magnitudes ($r = .627, .544$, respectively) in view of the amount of error introduced by list differences. Accordingly, it seems warranted to conclude that with regard to the first criterion of a proposed instrument for the classification of individuals, the present task is quite promising.

Correlations. Table 24 presents the matrices of intercorrelations of eight major variables separately for the samples of higher and lower-strata children. Note especially the different magnitudes of correlation between PA task variables and PPVT variables for the two strata groups. In general, both MA and IQ predict learning efficiency modestly well for higher-strata children but are unrelated to learning efficiency in lower-strata children.

Discussion

The main conclusions of the present experiment are clear. First, the pictorial PA task is quite appropriate for use in investigating learning processes in preschool children. Reliable differences in

Table 24
Intercorrelations Among Eight Variables for the
Higher- and for the Lower-Strata Samples

Higher Strata

	CA	MA	IQ	NS	NA	SS	SA
Chronological Age	--						
PPVT Mental Age	.41**	--					
PPVT IQ	-.01	.81**	--				
Naming Still	.38**	.53**	.39**	--			
Naming Action	.37**	.43**	.31**	.48**	--		
Sentence Still	.14	.43**	.41**	.55**	.55**	--	
Sentence Action	.32**	.52**	.42**	.61**	.54**	.58**	--
Total PA	.36**	.58**	.47**	.81**	.78**	.83**	.85**

Lower Strata

	CA	MA	IQ	NS	NA	SS	SA
Chronological Age	--						
PPVT Mental Age	.26**	--					
PPVT IQ	-.01	.81**	--				
Naming Still	.25*	-.02	.03	--			
Naming Action	.37**	.22*	.19	.36**	--		
Sentence Still	.39**	.26**	.26**	.32**	.55**	--	
Sentence Action	.28**	.14	.15	.44**	.71**	.48**	--
Total PA	.41**	.20*	.21*	.66**	.84**	.76**	.85**

* $p < .05$
** $p < .01$

learning efficiency as a function of experimental conditions can be detected even in this young population. Second, the PA task promises to have sufficient reliability to warrant its conversion into a test instrument for the purpose of classifying children with respect to learning proficiency. In relation to the latter, the third conclusion is that the PA task as a diagnostic instrument is less affected by differences in past opportunities for learning than are standard intelligence tests, here represented by the PPVT. Fourth, the PA task, when administered to pre-school children, is capable of reflecting the differences in learning proficiency that appear later, chronologically, in the academic performance of upper- and lower-strata school children.

Experiment XIII: School Strata, Conditions of Elaboration and Learning Proficiency

Despite the fact that the results of Experiment XII clearly demonstrated strata differences in learning efficiency, it remained to explicate the fact that in Experiments X and XI no such difference was found. The persisting question was: "Why do lower-strata children, whose performance on school-related learning tasks is inferior, learn as efficiently as upper-strata children on the film PA task?" In an attempt to answer this question, the hypothesis that initiated the present experiment was that the less the degree of environmental support for the use of elaboration on the learning task, the greater the likelihood that lower-strata children would perform less well than upper-strata children. A more specific form of this hypothesis contended that lower-strata children would benefit as much as upper-strata children from provided elaboration but that they would be deficient in generating elaborative structures that would successfully facilitate learning when these were requested by instructions but not provided by the experimenter.

Method

Subjects. Samples of 40 *S*s each were drawn randomly from kindergarten, first- and third-grade classes in a lower- and in an upper-strata elementary school. Thus the total sample numbered 240 children. Ten *S*s from each sub-sample were randomly assigned to each of the four experimental conditions such that an independent group of *S*s from each sample served under each of the conditions.

Materials and design. All *S*s were asked to learn the list of 20 film PAs described in Experiment XII by a pairing-test method. The four experimental conditions were distinguished principally in terms of the procedure followed on the first pairing trial. In the first condition, provided-phrase (PP), as each pair appeared on the screen, *E* uttered aloud the names of the two objects and the *S* repeated those names. Then the projector was stopped and *E* read aloud a conjunction phrase containing the names of the two objects that had been in view immediately before (e.g. The DOG and the little GATE) and this phrase was immediately repeated by *S*. The projector was then started, the next pair was exposed and the appropriate verbalizations were uttered by *E* and then by *S*. The same procedure was followed for every one of the 20 items in the list. A similar procedure was followed in the second condition, provided-sentence (PS) except that rather than reading a phrase containing the names of the two objects in each pair, the *E* read a sentence in which these two nouns were connected by a verb (e.g. The DOG closes the little GATE). In the third condition, generated-still (GS) when the projector was stopped after the first exposure of the pair, the *S* was asked to construct and utter a sentence about the two objects shown. The remainder of the procedure was the same as that followed in PP and PS. In all of the three conditions described thus far, the still or stationary version of the PA film materials was used. However, in the fourth condition, generated-action (GA) the action version of the materials was used. The procedure followed was identical to that for GS, the only difference between the two conditions being that of action vs. still pictures.

The procedure followed during the first pairing trial thus varied across experimental conditions. During the second pairing trial, however, the procedure was identical for all conditions, that is, as each pair appeared on the screen, the *E* uttered aloud the names of the two objects then in view while the *S* simply watched the screen and listened. Nevertheless, one difference did exist, even on the second pairing trial between GA and the other three conditions, namely, that action pictures were used in the case of the former while still pictures were used in all of the latter. The two test trials were completely identical for all four conditions: one item from each pair was presented on the screen and as each of these appeared, *E* uttered its name while *S* attempted to respond with the name of the other member of the pair. During the test trials, the items were presented at a 4-sec. rate in all conditions. The rate of presentation varied during the initial pairing trial, depending upon the experimental condition and, to permit an assessment of this variable, the amount of time expended during that trial was measured by means of a stopwatch and recorded for each *S*. In the two generation conditions, GS and GA, the sentences produced by the *Ss* were recorded verbatim by one of the two *Es* present in the testing room. A total of two pairing and two test trials were administered to all *Ss*.

Some discussion of the particular experimental conditions chosen for inclusion in the present experiment is in order. Recall first that the entire design is a three-way factorial in which the principal independent variables are Grades (K, 1, 3), Strata (upper vs. lower) and Conditions (PP, PS, GS, GA). Upper- and lower-strata children had been found previously (Experiments X and XI) to perform at equivalent levels under conditions of learning comparable to the present PP and PS conditions. Furthermore, a condition like PS had proven to be facilitory relative to PP for both kinds of populations. As for the two conditions in which *Ss* themselves were required to generate sentence elaborations for the PA task, one provided considerable stimulus support for this activity (GA) whereas the other did not (GS). In GA the *S*'s task was simply to construct a sentence describing an activity already represented to him visually. In GS, however, the activity was not made available.

The expectation following from the initiating hypothesis was that upper- and lower-strata *Ss* would perform at equivalent levels in PP, PS and GA but that upper-strata *Ss* would excel in GS, especially those in the kindergarten and first grade samples. Thus the experiment was intended to evaluate the notion that lower-strata children are deficient in the activity of self-initiated elaboration.

Results

Learning. Learning efficiency was indexed in terms of the numbers of correct responses made on the two test trials. The results are presented in Table 25 as a function of Grades, Strata

Table 25
Mean Numbers of Correct Responses as a Function of
Grades, Strata and Conditions

	Grades						
	K		1		3		
Conditions	Upper	Lower	Upper	Lower	Upper	Lower	Total
PP	11.80	10.40	12.30	8.95	11.90	11.80	11.19
PS	13.70	11.45	13.85	10.80	14.20	12.20	12.70
GS	13.05	10.95	13.75	12.10	14.55	16.15	13.42
GA	14.90	12.95	14.70	13.10	15.90	15.25	14.47
Total	13.36	11.44	13.65	11.24	14.14	13.85	

and Conditions. Analysis of variance (See Appendix M-1) revealed significant main effects associated with each of the principal variables: Grades, F (2,216) = 8.08, $p < .01$; Strata, F (1,216) = 17.47, $p < .01$; and Conditions, F (3,216) = 13.92, $p < .01$. Within the main effect for Grades, *post hoc* comparisons revealed no significant difference between the kindergarten and first-grade samples, both of which performed significantly less well than the third-grade sample. The latter outcome did little violence to what had been expected. In contrast, the main effect of Strata, in which the upper-strata sample performed better than the lower-strata sample was surprising and inconsistent with what had been observed in Experiment X. The strata difference poses the main interpretive task resulting from the present experiment.

Among the four experimental conditions, a variety of comparisons were made by the Tukey method: GA was superior to each of the other three conditions; GS was superior to the control condition, PP; PS was superior to PP; GS and PS did not differ significantly; and, the two generation sentence conditions were superior to the presented sentence condition.

The latter result, as well as that showing no difference between GS and PS must, in one sense, be taken as an underestimate of the facilitory effect of self-generated elaboration. This statement follows from a careful examination of the procedures followed in the two kinds of conditions. Specifically, during the initial pairing trial in the Presented conditions, the names of the two objects in each pair were uttered aloud a total of four times, twice by *E* and twice by *S*. In contrast, the names of the pair members were uttered aloud only three times in the Generated conditions, once by *E*, and twice by *S* (the latter is a maximum figure since *Ss* did not always include both names in the sentences they generated). As will be pointed out in the following section, however, this conclusion is not entirely supportable, since more time was consumed during the initial pairing trial by *Ss* in the Generated than by *Ss* in the Presented conditions. If the additional time was used to practice the pairs to be learned, then the present results overestimate rather than underestimate the superiority of self-generated elaboration. A more complete discussion of this problem will be provided shortly.

Neither the predicted interaction of Strata with Conditions, nor that of Grades, Strata and Conditions was significant, $F < 1$, in both cases. The two-way interaction of Grades and Strata, however, was significant, $F\ (2,216) = 3.04$, $p < .05$, such that the upper-strata samples were superior only in the Kindergarten and Grade 1 cases.

The only remaining significant effect of interest is the two-way interaction of Strata with Trials, $F\ (1,216) = 5.89$, $p < .05$. The form of this interaction, shown in Table 26, indicates that the superiority of upper-strata children is greater on trial 2 than on trial 1. Similar effects were detected in Experiment XII suggesting that lower-strata children may, in fact, benefit less than upper-strata children from simple repetition. As will become clear in the discussion of the present experiment, this suggestion will comprise the major interpretation provided for the observed inferiority of performance on the part of the lower-strata children.

Table 26
Mean Numbers of Correct Responses as a Function
of Strata and Trials

	Trials		
Strata	1	2	Total
Upper	11.23	16.20	13.72
Lower	10.04	14.31	12.17
Total	10.64	15.25	

Time. As previously noted, the amount of time consumed by each *S* in completing the initial pairing trial was recorded by *E*. Even though the relationship between pairing-trial time and performance on the learning task proper was negligible, $r\ (239) = -.006$, the following analysis was conducted since time is of interest in its own right. Time in minutes, as a dependent variable, was subjected to analysis of variance in which the principal factors were: Grades, Strata and Conditions. A summary of the analysis of variance is presented in Table 27 and the results relevant to those tests are presented in Table 28.

Table 27
Summary of Analysis of Variance Performed on Pairing-Trial Time

Source	df	Mean Square	F
Strata (S)	1	1.46	<1
Grades (G)	2	16.12	29.50**
Conditions (C)	3	39.98	73.17**
S x G	2	4.61	8.43**
S x C	3	4.65	8.50**
G x C	6	1.92	3.51**
S x G x C	6	2.43	4.45**
Subjects/SGC	216	.55	

** $p < .01$

Table 28
Mean Amounts of Pairing-Trial Time (in mins.) as a Function of Grades, Strata and Conditions

	Grades								
	K		1		3		Total		
	Upper	Lower	Upper	Lower	Upper	Lower	Upper	Lower	Total
PP	3.70	3.98	3.56	3.60	3.30	3.35	3.52	3.64	3.58
PS	4.12	4.19	3.80	3.83	3.44	3.57	3.79	3.86	3.83
GS	6.10	5.92	7.16	4.43	4.41	4.35	5.89	4.90	5.39
GA	4.18	4.53	4.05	3.86	3.45	3.79	3.89	4.06	3.98
Total	4.53	4.65	4.64	3.93	3.65	3.76	4.27	4.12	

With the exception of the main effect of strata, all of the tests performed in the analysis of variance were significant. Accordingly, assertions about any of the less complex effects must be tempered by what is revealed in the more complex interactions. A careful examination of the results with appropriate attention given to the qualifications required by the significant three-way interaction term, yields the following conclusions. The observed differences between Grades in the amount of time consumed during the initial pairing trial are located entirely within condition GS; in the lower-strata samples, Kindergarten Ss required more time than first- or third-graders, while in the upper-strata samples, both the Kindergarten and the first-grade samples required more time than the third grade sample. The main effect of conditions is located principally in the larger amount of time consumed in the GS condition than in the other three but, it must be noted, that this effect only holds for the lower-strata kindergarten, upper-strata kindergarten and upper-strata first-grade samples. Finally, the strata difference intimated by the significant two-way interactions of Strata x Grades and Strata x Conditions is attributable entirely to the larger amount of time taken in condition GS by the upper-strata first graders as compared with the lower-strata first graders.

Of all these significant effects, two are worth additional comment. The first concerns the larger amount of time required by the younger Ss in the GS condition. As expected, the task posed for the young child when he is required to generate a sentence about two objects depicted in a stationary manner is a difficult one. Apparently, additional training and/or maturation beyond that characteristic of kindergarten-age children is required before the task can be accomplished with facility. Secondly, it should be mentioned that in terms of the time measure, lower-strata first-grade children appear to have more facility in constructing sentences in the GS condition than do the upper-strata children. This result contradicts expectations about the differential language facility of lower- and upper-strata children and, therefore requires the closer examination provided by an analysis of the sentences produced by the children assigned to the two generation conditions.

Generated Sentences. The sentences produced by Ss in the GS and GA conditions can be scored in a large variety of ways. Three of the possible scores were chosen for analysis; the criterion for this choice was that the scores should index sentence properties of known or presumed relevance for PA learning. The three scores were: (a) the number of nouns from the PAs actually used in the sentences; (b) the number of sentences in which the form class of the connective linking the two nouns was verb; and, (c) the number of different verbs used in the sentences generated by each S.

Each of these dependent variables was subjected to analysis of variance in which the sources assessed were: Grades, Strata and Conditions (See Appendix M-2). The results for variable (a), number of nouns used, are presented in Table 29 as a function of the three independent variables. Only one significant source of variance emerged, namely, Grades, F (1,108) = 22.46, $p < .01$. Fewer nouns were included in sentences by the Kindergarten *S*s than by either the first- or the third-graders. The latter two did not differ. The main effect of Strata was not significant, $F < 1$, nor were any of its interactions.

Table 29
Mean Numbers of Nouns Used in Generated Sentences as a Function of Strata, Grades and Condition

	Strata				
	Upper		Lower		
Grades	GS	GA	GS	GA	Total
K	23.90	32.50	30.80	31.80	29.75
1	36.20	38.20	35.30	35.40	36.28
3	38.40	39.30	39.20	38.70	38.90
Total	32.83	36.67	35.10	35.30	

The results obtained in connection with variable (b), number of verb connectives, are shown in Table 30. Once again, Strata failed to account for a single significant source of variance. The main effect of conditions, however, was significant, F (1,108) = 18.97, $p < .01$; more verb connectives were used in the Action than in the Still condition. None of the other terms in the analysis of variance, including that of Grades, was significant.

Similarly, the only significant source of variance in variable (c), the number of different verbs used by each *S*, was Conditions, F (1,108) = 6.72, $p < .05$. As an inspection of the results presented in Table 31 indicates, a greater variety of verbs was used in the Action than in the Still condition. The main effect of Strata was negligible, $F < 1$, and none of its interactions were significant.

Discussion

Clearly, the present results contain no evidence to support the usual contention that lower-strata children are deficient in task-related language skills. Thus the problem remains to account for the fact that in contrast to Experiments X and XI, the upper-

Table 30
Mean Numbers of Verb Connectives Used in Generated Sentences as a Function of Strata, Grades and Conditions

	Strata				
	Upper		Lower		
Grades	GS	GA	GS	GA	Total
K	9.30	15.10	12.70	15.90	13.25
1	13.30	18.10	14.10	16.30	15.45
3	14.40	19.00	11.80	16.60	15.45
Total	12.33	17.40	12.86	16.20	

Table 31
Mean Numbers of Different Verbs Used in Generated Sentences as a Function of Strata, Grades and Conditions

	Strata				
	Upper		Lower		
Grades	GS	GA	GS	GA	Total
K	14.60	16.40	13.80	17.20	15.50
1	15.90	16.30	15.80	17.20	16.30
3	15.50	16.80	17.20	16.20	16.42
Total	15.33	16.50	15.60	16.87	

strata kindergarten and first-grade samples in the present study learned more efficiently than comparable lower-strata samples.

One interpretation is that the populations sampled in the three experiments were different. This possibility cannot be entirely discounted but the visible characteristics of the various populations were quite comparable. A more appealing interpretation is that the difference in results should be attributed to the procedural difference emphasized earlier, that is, to the larger number of pairing-trial repetitions of each PA item that occurred in the present experiment. As noted, the lower-strata samples benefit less from inter-trial repetition than do the upper-strata samples. If this effect can be generalized to intra-trial repetitions, it accounts for the observed discrepancy among the various experiments. In this connection, it is interesting that the results of the present experiment are entirely consistent with those reported by Semler and Iscoe (37). It will be recalled that in the latter investigation a multi-trial procedure was followed, which, according to the repetition hypothesis, would have permitted the emergence of a strata difference in the five- and six-year old samples.

Conclusions, Implications and Recommendations

Since the conclusions that follow from the work done in the present project have already been stated and discussed, it only remains to enumerate them concisely and to detail their implications.

Elaborative Facilitation

A number of the experiments performed in connection with the topic of elaborative facilitation were concerned with the form-class effect initially reported by Rohwer (33). That is to say, the purpose of these experiments was to evaluate explanations of the differential effects produced by conjunction, preposition and verb connectives on noun-pair learning. The relevant conclusions are as follows:

i. The form-class effect is not attributable to the fact that the degree of formal intralist similarity is lower in lists of verb and preposition strings than in lists of conjunction strings.

ii. Nor is the form-class effect attributable to the greater degree of semantic constraint exerted on subsequent string components by verb than by conjunction connectives.

iii. Entire verb strings, or sentences, are easier to learn than entire conjunction strings, or phrases, when matched for number of words to be recalled.

iv. Nevertheless, the superiority of verb over conjunction connectives in promoting efficient noun-pair learning cannot be attributed to the greater availability of the verb string context during recall.

v. The form-class effect is not attributable to a process whereby Ss select the verb from a sentence context as the functional stimulus.

vi. The form-class effect is not due to differences in implied overt activity as between verb and conjunction connectives.

vii. Normal sentences facilitate the learning of constituent noun pairs whereas anomalous sentences do not.

viii. The presence or absence of adjective modifiers does not affect the learning of noun pairs presented in sentences.

ix. Even though matched for number and identity of words, sentences in which the two nouns are connected by a verb promote more efficient noun-pair learning than sentences in which the nouns are connected by a conjunction.

x. The learning of serial lists of nouns as well as the learning of PA lists of nouns can be facilitated by the presentation of the nouns in sentence contexts, if, and only if, the structure of the sentences is isomorphic with the structure of the memory storage used in the particular form of learning in question.

These conclusions have the following major implications. (a) Verbal mediation theory does not adequately encompass the form-class effect found in research on elaborative facilitation. The major obstacles to a mediation explanation of the form-class effect are that it assumed the existence of connections or associations between individual verbal units (i.e. words), which appear to be irrelevant to the effect, and that it requires the existence of stronger links based on more frequent previous contiguity, between the elements in a noun-verb-noun configuration than in a noun-conjunction-noun or a noun-noun configuration, which simply appears to be false. (b) Therefore, research on elaborative facilitation should be directed at the question of the form of memory storage in learning, at the question of the nature of the processes that produce these forms of storage, and at the question of the temporal locus of these processes. (c) In view of the observed variation in the amount of facilitation produced by sentence contexts, the effects of variables other than those referred to in points i. through x. above must be investigated.

Other conclusions pertain to the second form of elaboration subjected to experimental analysis in the present project, namely, pictorial elaboration.

xi. For elementary school children, a list of paired objects is easier to learn when the objects are represented pictorially than when represented verbally.

xii. Furthermore, the efficiency of learning pictorially presented pairs varies as a function of the manner in which the two members of a pair are depicted relative to one another.

xiii. The functions relating manner of depiction (Still, Locational, Action) to learning efficiency, and connective form class (Conjunction, Preposition, Verb) to learning efficiency are remarkably parallel.

xiv. The nature of the process or processes responsible for this parallelism is indeterminate.

xv. The question whether verbal or visual elaborative processes have developmental primacy remains unanswered since the function relating manner of depiction to learning efficiency was found to be invariant across the elementary-school age range.

The general implications of these conclusions are of two kinds. First, of course, it is clear that additional research is needed to specify the nature and developmental course of elaborative processes in children. Secondly, it is equally clear that the manner in which materials are presented for learning dramatically affects learning efficiency. In view of the latter it is in order now to undertake research in which the principles of facilitation isolated here are applied to the presentation of school-learning types of materials.

Finally, it is in order to recommend that research on elaborative facilitation should take on an additional dimension. In view of the marked effects visual and verbal forms of elaboration can have on the efficiency of initial learning, it is important to examine the possibility that elaborative activities can affect retention as well. In this connection, two kinds of investigation are envisioned. The first is concerned with studies of simple retention over varying lengths of time. The second kind would be designed to examine the effects of elaboration on the learning of successive lists of nouns and on the recall of previous lists after interpolated learning has intervened.

Elaboration and Learning Proficiency

The conclusions derived from the present studies of the relationship between elaboration and learning proficiency are the following.

xvi. Under optimal conditions of learning, lower-strata or culturally disadvantaged children, six years of age and older, are not inferior to upper-strata children either in basic PA learning proficiency or in ability to benefit from elaborative forms of presenting learning materials.

xvii. Inferior performance among lower-strata, five and six year old children does emerge when the task involves multiple repetitions of the learning materials.

xviii. No evidence was found to support the contention that the latter effect is due to strata differences in the ability to produce sentence elaboration.

xix. In the pre-school age range (three to five years of age) inferior performance among lower-strata children is observed even under optimal conditions of learning.

xx. The PPVT predicts learning proficiency moderately well among upper-strata children but is unrelated to learning proficiency in lower-strata children.

xxi. The film material PA task used in the present project promises to be of considerable utility, when appropriately modified, as a test for identifying and classifying learning deficiencies in young children and for distinguishing between cultural and familial retardates.

The implications and related recommendations that follow from these conclusions are: (a) that research continue on the problem of isolating the specific locus of learning deficiency among young, lower-strata children with particular attention to the apparent inability of such children to make maximal use of repetition; (b) that the film PA task be developed into a test of learning proficiency for the purpose of classifying children with respect to deficiencies and to the types of remediation needed; and, (c) that methods for training young children in the use of elaborative techniques in learning be developed and evaluated.

Summary

The present project was concerned with two major topics: the phenomenon of elaborative facilitation of learning in children; and, the exploration of relationships between elaboration and learning proficiency in children. The notion of elaboration was obviously central in the project. Roughly, elaboration can be thought of as a process in which elements are added to those that a subject is asked to learn. Thus, the phenomenon of elaborative facilitation is that when such additional elements are of a particular kind, learning is easier than when they are not present. A paradox is posed by this observation; by increasing the amount of material to be processed, learning is facilitated. More specifically, for the purposes of this project, the prototypic form of the phenomenon was the result of an experiment reported by Rohwer (33). Sixth-grade children were asked to learn a list of eight paired nouns. During the initial presentation of the pairs, the verbal context in which they appeared was varied. The effects of four different conditions of presentation were evaluated: control, in which just the two nouns in each pair were presented (e.g. COW BALL); conjunction, in which the nouns were presented in phrases containing a conjunction as the connective (The COW and the BALL); preposition, in which the

contextual phrases contained a preposition connective (e.g. The COW behind the BALL); and, verb, in which the nouns appeared in sentences (The COW chases the BALL.). The results of the experiment were that the verb and preposition conditions produced significantly greater amounts of learning than the conjunction and control conditions. This form-class effect was the principal object of inquiry in connection with the first topic of concern in the present project, namely, that of elaborative facilitation.

Elaborative Facilitation

Nine different experiments were performed in an attempt (a) to evaluate proposed explanations of the form-class effect, (b) to ascertain the generality of elaborative facilitation across tasks and age groups, and (c) to examine the relationship between the verbal variable of connective form class and a comparable pictorial variable. The results of these experiments are summarized in the following set of conclusions.

i. The form-class effect is not attributable to the fact that the degree of formal intralist similarity is lower in lists of verb and preposition strings than in lists of conjunction strings.

ii. Nor is the form-class effect attributable to the greater degree of semantic constraint exerted on subsequent string components by verb than by conjunction connectives.

iii. Entire verb strings, or sentences, are easier to learn than entire conjunction strings, or phrases, when matched for number of words to be recalled.

iv. Nevertheless, the superiority of verb over conjunction connectives in promoting efficient noun-pair learning cannot be attributed to the greater availability of the verb string context during recall.

v. The form-class effect is not attributable to a process whereby Ss select the verb from a sentence context as the functional stimulus.

vi. The form-class effect is not due to differences in implied overt activity as between verb and conjunction connectives.

vii. Normal sentences facilitate the learning of constituent noun pairs whereas anomalous sentences do not.

viii. The presence or absence of adjective modifiers does not affect the learning of noun pairs presented in sentences.

ix. Even though matched for number and identity of words, sentences in which the two nouns are connected by a verb promote more efficient noun-pair learning than sentences in which the nouns are connected by a conjunction.

x. The learning of serial lists of nouns as well as the learning of PA lists of nouns can be facilitated by the presentation of the nouns in sentence contexts, if, and only if, the structure of the sentences is isomorphic with the structure of the memory storage used in the particular form of learning in question.

xi. For elementary school children, a list of paired objects is easier to learn when the objects are represented pictorially than when represented verbally.

xii. Furthermore, the efficiency of learning pictorially presented pairs varies as a function of the manner in which the two members of a pair are depicted relative to one another.

xiii. The functions relating manner of depiction (Still, Locational, Action) to learning efficiency, and connective form class (Conjunction, Preposition, Verb) to learning efficiency are remarkably parallel.

xiv. The nature of the process or processes responsible for this parallelism is indeterminate.

xv. The question whether verbal or visual elaborative processes have developmental primacy remains unanswered since the function relating manner of depiction to learning efficiency was found to be invariant across the elementary-school age range.

Elaboration and Learning Proficiency

The second major topic of concern in the present proposal was that of the relationship between certain subject variables, (specifically, social-class membership, age, and IQ) learning proficiency and elaboration. Experiments were designed to determine the relative status of children from culturally disadvantaged populations with respect to learning proficiency and to estimate the extent to which such children could benefit from the use of techniques of elaborative facilitation. An effort was made to specify the locus of learning deficiency in lower-strata children and to commence work on the development of a learning test to appropriately identify these deficiencies. The results of the four experiments conducted in this connection yielded the following conclusions.

xvi. Under optimal conditions of learning, lower-strata or culturally disadvantaged children, six years of age and older, are not inferior to upper-strata children either in basic PA learning proficiency or in ability to benefit from elaborative forms of presenting learning materials.

xvii. Inferior performance among lower-strata, five and six year old children does emerge when the task involves multiple repetitions of the learning materials.

xviii. No evidence was found to support the contention that the latter effect is due to strata differences in the ability to produce sentence elaboration.

xix. In the pre-school age range (three to five years of age) inferior performance among lower-strata children is observed even under optimal conditions of learning.

xx. The PPVT predicts learning proficiency moderately well among upper-strata children but is unrelated to learning proficiency in lower-strata children.

xxi. The film material PA task used in the present project promises to be of considerable utility, when appropriately modified, as a test for identifying and classifying learning deficiencies in young children and for distinguishing between cultural and familial retardates.

A set of implications derived from the research performed in the project and the resulting recommendations made are pertinent to both theoretical and to applied issues. Some of the former include the theory of verbal mediation, the form of memory storage in children, developmental differences in the nature of elaborative processes, determinants of the magnitude of elaborative facilitation, the effects of elaboration on retention, and, the distinction between cultural and familial retardation. With respect to topics of more applied significance, implications and recommendations concerned methods for presenting learning materials to children, methods for increasing the learning proficiency of children, the development of a diagnostic instrument for the indentification of loci of learning deficiencies, and the development of procedures for remediating these deficits.

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Appendix A-1

Summary Analysis of Variance Table for Mean Numbers of Correct Responses: Experiment I

Source	df	Mean Square	F
Treatments (T)	6	20.05	2.19
Conj. vs. All	1	114.76	12.54**
Form Class (F)	1	1.25	--
Intralist Similarity (S)	2	1.63	--
F x S	2	.52	--
Lists (L)	1	9.33	1.02
T x L	6	9.11	--
Subjects/T x L	98	9.15	
Trials (Tr)	2	228.49	172.64**
T x Tr	12	1.29	--
L x Tr	2	.57	--
T x L x Tr	12	.97	--
Subjects x Tr/T x L	196	1.32	

** $p < .01$

Appendix A-2

Summary Analysis of Variance Table for Mean Percentages of Intralist Intrusions

Source	df	Mean Square	F
Treatments (T)	6	.159	1.63
Conj. vs. All	1	.688	7.04**
Form Class (F)	1	.075	--
Intralist Similarity (S)	2	.072	--
F x S	2	.024	--
Lists (L)	1	.194	1.99
T x L	6	.096	--
Subjects/T x L	98	.098	

** $p < .01$

Appendix B-1
Summary Analysis of Variance Table for Mean Numbers of Correct Responses: Experiment II (Original Experiment)

Source	df	Mean Square	F
Form Class (F)	1	288.29	10.51**
Response Mode (R)	1	388.79	14.17**
F x R	1	20.83	--
Subjects/F x R	56	27.44	
Trials (T)	1	1020.83	242.93**
F x T	1	4.80	1.14
R x T	1	0.83	--
F x R x T	1	1.20	--
Subjects x T/F x R	56	4.20	

* $p < .01$

Appendix B-2

Summary Analysis of Variance Table for Mean Numbers of Correct Responses: Experiment II (Replication I); Design I

Source	df	Mean Square	F
Ability (A)	3	19.78	1.59
Grades (G)	1	51.26	4.13
Form Class (F)	1	698.44	56.26**
Response Mode (R)	1	347.82	28.02**
A x G	3	10.72	--
A x F	3	2.24	--
A x R	3	12.65	1.02
G x F	1	1.32	--
G x R	1	4.13	--
F x R	1	4.88	--
A x G x F	3	6.53	--
A x G x R	3	.63	--
A x F x R	3	.47	--
G x F x R	1	110.63	8.91**
A x G x F x R	3	22.05	1.78
Subjects/A x G x F x R	31	12.41	
Trials (T)	1	908.44	258.82**
A x T	3	1.53	--
G x T	1	.20	--
F x T	1	.07	--
R x T	1	.20	--
A x G x T	3	2.53	--
A x F x T	3	5.40	1.54
A x R x T	3	.57	--
G x F x T	1	1.76	--
G x R x T	1	.07	--
F x R x T	1	1.76	--
A x G x F x T	3	1.84	--
A x G x R x T	3	9.61	2.74
A x F x R x T	3	4.72	1.34
G x F x R x T	1	1.32	--
A x G x F x R x T	3	1.94	--
Subjects x T/A x G x F x R	31	3.51	

** $p < .01$

Appendix B-3

Summary Analysis of Variance Table for Mean Numbers of Correct Responses: Experiment II (Replication I); Design 2

Source	df	Mean Square	F
Ability (A)	3	16.81	1.11
Grades (G)	1	12.50	--
Form Class (F)	1	810.03	53.55**
Response Mode (R)	1	.78	--
A x G	3	2.52	--
A x F	3	11.34	--
A x R	3	6.72	--
G x F	1	3.78	--
G x R	1	2.53	--
F x R	1	18.00	1.19
A x G x F	3	17.55	1.16
A x G x R	3	6.84	--
A x F x R	3	2.77	--
G x F x R	1	55.12	3.64
A x G x F x R	3	2.19	--
Subjects/A x G x F x R	30	15.12	
Trials (T)	1	871.53	173.21**
A x T	3	4.43	--
G x T	1	5.28	1.05
F x T	1	.12	--
R x T	1	1.12	--
A x G x T	3	11.55	2.30
A x F x T	3	5.85	1.16
A x R x T	3	3.65	--
G x F x T	1	.12	--
G x R x T	1	4.50	--
F x R x T	1	1.53	--
A x G x F x T	3	.81	--
A x G x R x T	3	3.06	--
A x F x R x T	3	2.88	--
G x F x R x T	1	.03	--
A x G x F x R x T	3	3.01	--
Subjects x T/A x G x F x R	30	5.03	

** $p < .01$

Appendix B-4

Summary Analysis of Variance Table for Mean Numbers of Correct Responses: Experiment II (Replication II); Design 1

Source	df	Mean Square	F
Grades (G)	1	11.88	--
Form Class (F)	1	929.88	41.20**
Response Mode (R)	1	17.26	--
G x F	1	48.76	2.16
G x R	1	35.07	1.55
F x R	1	5.70	--
G x F x R	1	6.57	--
Subjects /G x F x R	56	22.57	
Trials (T)	1	984.57	230.63**
T x G	1	4.88	1.14
T x F	1	2.82	--
T x R	1	10.70	2.51
T x G x F	1	.94	--
T x G x R	1	.63	--
T x F x R	1	.07	--
T x G x F x R	1	2.82	--
Subjects x T/G x F x R	56	4.27	

** $p < .01$

Appendix B-5

Summary Analysis of Variance Table for Mean Numbers of Correct Responses: Experiment II (Replication II); Design 2

Source	df	Mean Square	F
Grades (G)	1	7.03	--
Form Class (F)	1	780.12	37.57**
Response Mode (R)	1	19.53	--
G x F	1	40.50	1.95
G x R	1	.03	--
F x R	1	24.50	1.18
G x F x R	1	10.12	--
Subjects/G x F x R	56	20.77	
Trials (T)	1	957.03	176.51**
T x G	1	.78	--
T x F	1	8.00	1.48
T x R	1	13.78	2.54
T x G x F	1	10.12	--
T x G x R	1	.28	--
T x F x R	1	2.00	--
T x G x F x R	1	.00	--
Subjects x T/G x F x R	56	5.42	

** $p < .01$

Appendix C-1

Summary Analysis of Variance Table for Mean Numbers of Correct Responses: Experiment III

Source	df	Mean Square	F
Grades (G)	1	6.51	--
Conditions (C)	5	124.06	8.28**
Lists (L)	1	20.17	1.35
G x C	5	9.91	--
G x L	1	1.04	--
C x L	5	24.42	1.63
G x C x L	5	6.13	--
Subjects/G x C x L	72	14.98	
Trials (T)	3	275.91	128.33**
G x T	3	6.61	3.07*
C x T	15	2.73	1.27
L x T	3	5.42	2.52
G x C x T	15	1.57	--
G x L X T	3	1.67	--
C x L x T	15	1.30	--
G x C x L X T	15	2.57	1.20
Subjects x T/G x C x L	216	2.15	

* $p < .05$
** $p < .01$

Appendix D-1

Summary Analysis of Variance Table for Mean Numbers of Strings Recalled: Experiment IV

Source	df	Mean Square	F
Tasks (T)	2	242.39	12.87**
Grades (G)	1	.12	--
Connectives (C)/T	3	87.15	4.63**
C/PA-CS	1	26.04	1.38
C/CS-CS	1	100.04	5.31*
C/FS-FS	1	135.38	7.19*
Lists (L)	1	1.68	--
T x G	2	18.17	--
T x L	2	32.72	1.74
G x C/T	3	3.48	--
G x L	1	6.12	--
C/T x L	3	17.38	--
T x G x L	2	17.17	--
G x C/T x L	3	25.82	1.37
Subjects/G x C/T x L	48	18.83	

* $p < .05$
** $p < .01$

Appendix D-2

Summary Analysis of Variance Table for Mean Numbers of Words Recalled: Experiment IV

Source	df	Mean Square	F
Tasks (T)	2	276.56	10.96**
Grades (G)	1	17.51	--
Connectives (C)/T	3	96.11	3.81*
C/PA-CS	1	77.18	3.06
C/CS-CS	1	91.05	3.61
C/FS-FS	1	120.05	4.76*
Lists (L)	1	.72	--
T x G	2	44.16	1.75
T x L	2	18.03	--
G x C/T	3	6.77	--
G x L	1	.26	--
C/T x L	3	19.65	--
T x G x L	2	18.01	--
G x C/T x L	3	70.48	2.79
Subjects/G x C/T x L	48	25.22	
Trials (Tr)/T	6	225.30	93.13**
Constituent (Co)/T	9	20.73	12.22**
Tr/T x G	6	1.99	--
Tr/T x C/T	6	2.31	--
Tr/T x L	6	3.96	1.64
Co/T x G	9	2.26	1.32
Co/T x C/T	9	11.23	6.62**
Co x C/PA-CS	3	18.71	11.02**
Co x C/CS-CS	3	12.46	7.34**
Co x C/FS-FS	3	2.53	1.49
Co/T x L	9	2.47	1.45
Tr/T x Co/T	18	1.39	1.96*
Tr/T x C/T x G	6	3.10	1.28
Tr/T x G x L	6	1.34	--
Tr/T x C/T x L	6	2.06	--
Co/T x C/T x G	9	1.61	--
Co/T x G x L	9	3.00	1.76
Co/T x C/T x L	9	3.93	2.31*
Tr/T x Co/T x G	18	.29	--
Tr/T x Co/T x C/T	18	1.34	1.88*
Tr/T x Co/T x L	18	.93	1.31
Tr/T x C/T x G x L	6	4.43	1.83

Appendix D-2 (continued)

Source	df	Mean Square	F
Co/T x C/T x G x L	9	3.82	2.24*
Tr/T x C/T x Co/T x G	18	.83	1.17
Tr/T x Co/T x G x L	18	.57	--
Tr/T x Co/T x C/T x L	18	1.06	1.49
Tr/T x Co/T x C/T x G x L	18	.67	--
Subjects x Tr/T/G x C/T x L	96	2.42	
Subjects x Co/T/G x C/T x L	144	1.70	
Subjects x Tr/T x Co/T/G x C/T x L	288	.71	

* $p < .05$
** $p < .01$

Appendix E-1

Summary Analysis of Variance Table for Mean Numbers of Correct Responses: Experiment V

Source	df	Mean Square	F
Grades (G)	1	22.89	2.06
Within G	206	11.12	
Control vs. All/G	2	9.50	1.43
Locus (L)/G	4	125.59	18.86**
Form Class (F)/G	2	152.04	22.83**
Modifiers (M)/G	2	.17	--
L x F/G	4	46.93	7.05**
L x M/G	4	6.21	--
F x M/G	2	3.74	--
L x F x M/G	4	8.52	1.28
Subjects/L x F x M/G	182	6.66	

** $p < .01$

Appendix F-1
Summary Analysis of Variance Table for Mean Numbers of Correct Responses: Experiment VI

Source	df	Mean Square	F
String Type (S)	1	121.00	15.68**
Form Class (F)	1	84.03	10.89**
S x F	1	9.00	1.17
Subjects/S x F	68	7.72	
Trials (T)	1	348.44	234.47**
T x S	1	3.36	2.26
T x F	1	.11	--
T x S x F	1	.03	--
Subjects x T/ S x F	68	1.49	

** $p < .01$

Appendix G-1

Summary Analysis of Variance Table for Mean Numbers of Correct Responses: Experiment VII

Source	df	Mean Square	F
Controls vs. All	1	16.09	2.87
Control N vs. Control A	1	1.00	--
Meaningfulness (M)	1	165.38	29.52**
Activity (A)	1	1.50	--
Test Stimuli (T)	2	135.16	24.13**
M x A	1	.04	--
M x T	2	9.50	1.70
A x T	2	2.37	--
M x A x T	2	5.24	--
Subjects/conditions	98	5.60	

** $p < .01$

Appendix H-1

Summary Analysis of Variance Table for Mean Numbers of Correct Responses: Experiment VIII

Source	df	Mean Square	*F*
Grades (G)	1	27.63	1.41
Materials (M)	1	2395.00	122.24**
Verbalization (V)	3	267.02	13.63**
Experimenters (E)	1	2.50	--
G x M	1	3.96	--
G x V	3	11.48	--
G x E	1	70.90	3.62
M x V	3	54.06	2.76*
M x E	1	43.34	2.21
V x E	3	42.21	2.15
G x M x V	3	67.67	3.45*
G x M x E	1	.75	--
G x V x E	3	18.62	--
M x V x E	3	57.07	2.91*
G x M x V x E	3	25.42	1.30
Subjects/G x M x V x E	160	19.59	
Trials (T)	1	4088.57	1393.61**
G x T	1	2.50	--
M x T	1	3.96	1.35
V x T	3	10.09	3.44*
E x T	1	0.21	--
G x M x T	1	13.13	4.47*
G x V x T	3	5.13	1.75
G x E x T	1	9.69	3.30
M x E x T	1	2.50	--
V x E x T	3	1.95	--
G x M x V x T	3	0.59	--
G x M x E x T	1	0.13	--
G x V x E x T	3	1.75	--
M x V x E x T	3	2.79	--
G x M x V x E x T	3	7.32	2.50
Subjects x T/G x M x V x E	160	2.93	

* $p < .05$

** $p < .01$

Appendix I-1

Summary Analysis of Variance Table for Mean Numbers of Correct Responses: Experiment IX

Source	df	Mean Square	F
Grades (G)	2	571.16	28.74**
Verbalization (V)	3	130.78	6.58**
Depiction (D)	2	549.65	27.66**
G x V	6	21.75	1.09
G x D	4	16.77	--
V x D	6	47.35	2.38*
G x V x D	12	23.44	1.18
Subjects/G x V x D	396	19.87	
Trials (T)	3	8219.89	2899.16**
T x G	6	8.01	2.82**
T x V	9	14.46	5.10**
T x D	6	46.63	16.45**
T x G x V	18	2.97	1.05
T x G x D	12	5.77	2.04*
T x V x D	18	2.72	--
T x G x V x D	36	3.64	1.28
Subjects x T/G x V x D	1188	2.84	

* $p < .05$
** $p < .01$

Appendix J-1

Summary Analysis of Variance Table for Mean Numbers of Correct Responses: Experiment X

Source	df	Mean Square	F
School Strata (S)	1	.12	--
Grades (G)	2	360.46	20.51**
Depiction (D)	1	1908.17	108.56**
Verbalization (V)	2	617.95	17.58**
S x G	2	16.78	--
S x D	1	8.56	--
S x V	2	21.57	1.22
G x D	2	16.27	--
G x V	4	65.03	3.70**
D x V	2	255.03	14.51**
S x G x D	2	19.88	1.13
S x G x V	4	7.11	--
S x D x V	2	47.02	2.67
G x D x V	4	22.12	1.26
S x G x D x V	4	7.23	--
Subjects/S x G x D x V	396	17.58	
Trials (T)	1	7210.67	2585.39**
S x T	1	26.04	9.34**
G x T	2	13.20	4.73**
D x T	1	10.67	3.82
V x T	2	5.15	1.85
S x G x T	2	5.28	1.89
S x D x T	1	9.38	3.36
S x V x T	2	9.90	3.55*
G x D x T	2	.45	--
G x V x T	4	2.67	--
D x V x T	2	2.21	--
S x G x D x T	2	1.84	--
S x G x V x T	4	3.61	1.29
S x D x V x T	2	.20	--
G x D x V x T	4	3.15	1.13
S x G x D x V x T	4	.65	--
Subjects x T/S x G x D x V	396	2.79	

* $p < .05$
** $p < .01$

Appendix K-1

Summary Analysis of Variance Table for Mean Numbers of Correct Responses: Experiment XI

Source	df	Mean Square	F
Groups (G)	8	623.78	25.76**
Populations (P)	1	2499.28	103.22**
Strata (S)	1	13.02	--
Grades (Gr)	3	776.62	32.07**
S x Gr	3	49.49	2.04
Depiction (D)	1	1166.68	48.18**
Verbalization (V)	1	547.85	22.63**
D x V	1	444.91	18.37**
G x D	8	16.75	--
P x D	1	2.83	--
S x D	1	22.69	--
Gr x D	3	15.15	--
Gr x S x D	3	21.01	--
G x V	8	17.19	--
P x V	1	12.33	--
S x V	1	46.02	1.90
Gr x V	3	18.65	--
S x Gr x V	3	7.74	--
G x D x V	8	24.40	1.01
P x D x V	1	.60	--
S x D x V	1	126.75	5.24*
Gr x D x V	3	20.31	--
Gr x S x D x V	3	2.31	--
Subjects/G x D x V	396	24.21	

* $p < .05$
** $p < .01$

Appendix L-1

Summary Analysis of Variance Table for Mean Numbers of Correct Responses: Experiment XII

Source	df	Mean Square	F
Lists (L)	3	13.89	2.42
Strata (S)	1	145.13	25.33**
Age (A)	1	207.21	36.16**
L x S	3	11.32	1.98
L x A	3	10.51	1.83
S x A	1	3.51	--
L x S x A	3	17.45	3.04*
Subjects/L x S x A	144	5.73	
Trials (T)	1	355.96	402.76**
L x T	3	2.04	2.31
S x T	1	11.06	12.51**
A x T	1	15.98	18.08**
L x S x T	3	2.22	2.51
L x A x T	3	1.82	2.06
S x A x T	1	.18	--
L x S x A x T	3	1.73	1.96
Subjects x T/L x S x A	144	.88	
Verbalization (V)	1	54.04	46.37**
L x V	3	15.98	13.71**
S x V	1	14.24	12.22**
A x V	1	3.51	3.01
L x S x V	3	1.50	1.29
L x A x V	3	.79	--
S x A x V	1	.41	--
L x S x A x V	3	.85	--
Subjects x V/L x S x A	144	1.16	
Depiction (D)	1	15.53	13.35**
L x D	3	31.02	26.68**
S x D	1	.04	--
A x D	1	.66	--
L x S x D	3	1.83	1.57
L x A x D	3	1.69	1.45
S x A x D	1	1.58	1.36
L x S x A x D	3	2.50	2.15
Subjects x D/L x S x A	144	1.16	

Appendix L-1 (continued)

Source	df	Mean Square	F
T x V	1	.00	--
L x T x V	3	1.17	2.69*
S x T x V	1	.75	1.72
A x T x V	1	1.88	4.32*
L x S x T x V	3	1.00	2.30
L x A x T x V	3	.05	--
S x A x T x V	1	.57	1.31
L x S x A x T x V	3	.61	1.40
Subjects x T x V/L x S x A	144	.44	
T x D	1	.34	--
L x T x D	3	3.52	6.62**
S x T x D	1	.23	--
A x T x D	1	.00	--
L x S x T x D	3	.66	1.24
L x A x T x D	3	1.70	3.20*
S x A x T x D	1	.04	--
L x S x A x T x D	3	.54	1.02
Subjects x T x D/L x S x A	144	.53	
V x D	1	.49	--
L x V x D	3	17.85	17.54**
S x V x D	1	.04	--
A x V x D	1	.09	--
L x S x V x D	3	.34	--
L x A x V x D	3	3.41	3.35*
S x A x V x D	1	.41	--
L x S x A x V x D	3	.83	--
Subjects x V x D/L x S x A	144	1.02	
T x V x D	1	.41	--
L x T x V x D	3	1.43	2.24
S x T x V x D	1	.23	--
A x T x V x D	1	.41	--
L x S x T x V x D	3	.38	--
L x A x T x V x D	3	.91	1.42
S x A x T x V x D	1	.28	--
L x S x A x T x V x D	3	.75	1.17
Subjects x T x V x D/L x S x A	144	.64	

* $p < .05$
** $p < .01$

Appendix M-1

Summary Analysis of Variance Table for Mean Numbers of Correct Responses: Experiment XIII

Source	df	Mean Square	F
Strata (S)	1	285.21	17.47**
Grades (G)	2	131.85	8.08**
Conditions (C)	3	227.20	13.92**
S x G	2	49.56	3.04*
S x C	3	15.01	--
G x C	6	16.04	--
S x G x C	6	8.50	--
Subjects/ S x G x C	216	16.32	
Trials (T)	1	2557.63	1025.53**
S x T	1	14.70	5.89*
G x T	2	3.22	1.29
C x T	3	7.37	2.96*
S x G x T	2	.12	--
S x C x T	3	4.32	1.73
G x C x T	6	3.54	1.42
S x G x C x T	6	8.16	3.27**
Subjects x T/S x G x C	216	2.49	

* $p < .05$
** $p < .01$

Appendix M-2

Summary Analysis of Variance Table for Mean Numbers of (a) Nouns, (b) Verb Connectives, and (c) Different Verbs used in Generated Sentences: Experiment XIII

		(a)		(b)		(c)	
Source	df	Mean Square	F	Mean Square	F	Mean Square	F
Strata (S)	1	6.08	--	2.70	--	3.01	--
Grades (G)	2	887.92	22.46**	64.53	2.28	10.08	1.52
Conditions (C)	1	122.01	3.09	537.63	18.97**	44.41	6.72*
S x G	2	62.18	1.57	53.20	1.88	.81	--
S x C	1	99.01	2.50	20.83	--	.08	--
G x C	2	59.91	1.52	4.13	--	15.76	2.38
S x G x C	2	29.66	--	6.53	--	11.02	1.67
Subjects/ S x G x C	108	39.54		28.34		6.61	

* $p < .05$
** $p < .01$